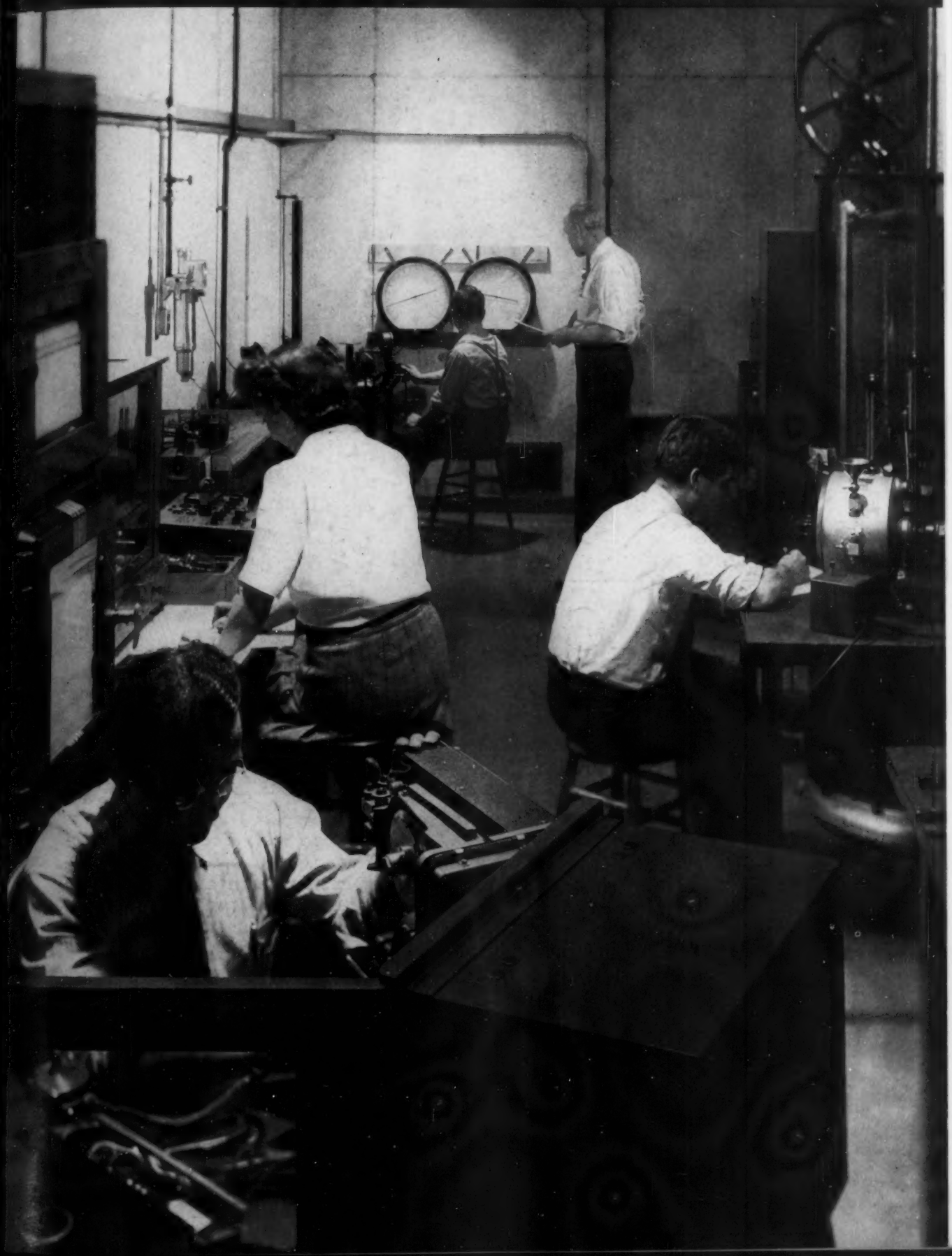
AY 1947
L. 20 No. 5

Instruments

THE MAGAZINE of MEASUREMENT and CONTROL



WHEN *SPEED* IS THE *NEED*

Only TAG *gives you...*

- **2 SPEED RECORDING**—Fast (3 to 6 seconds) or slow (30 to 60 seconds).
- **NO FALSE RECORDS**—Prints only when in balance.
- **VARIABLE CHART FEED**—Adjustable to 5 speeds.
- **CONTINUOUS ACTION**—Minimum of moving parts.

Write for the TAG CELECTRAY *Pyrometer Catalog No. 1101-H*

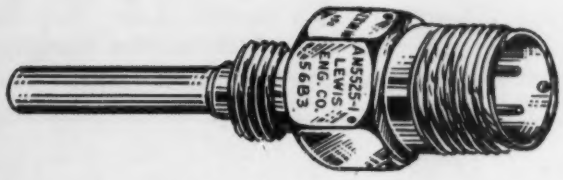
There is a complete line of TAG Celectray Pyrometers, all featuring high-speed photo-electric action and extreme accuracy. *Large illustration shows 29 of 350 Celectray Recorders in the control room of a prominent oil refinery.*

always specify TAG

C. J. TAG*liabue Division*

FOXBORO PRODUCTS CORPORATION
Brooklyn 5, New York

—THE LEWIS RESISTANCE BULB—



MODEL 56B3
(AN5525-1)

THE LEWIS RESISTANCE BULB MEETS EXACTING SPECIFICATIONS

✓ **RESPONSE TIME** — Averages 5 seconds from 100°C to 10°C when taken from boiling water to an ice bath.

✓ **HERMETICALLY SEALED** — Silver Soldered Assembly, by means of modern induction heating methods. The Terminal Pins are sealed in glass to the metal cap as in electronic tubes.

✓ **HIGH TEMPERATURE OPERATION** — Built to withstand a test temperature of 300°C for one minute. Bulbs model 56B5C and 56B6 will withstand operating temperatures of 500°F for a minimum of 500 hours. Model 56B6D will withstand 300°C for a minimum of 8 hours.

✓ **TOUGH** — Built to "take it" of Stainless Steel. The stem is of 18-8 type 304 (AMS5560A) and the head is constructed of Type 303 (AMS5640B). Polarizing Pin is of unique construction to prevent bending, twisting, or becoming loose.

✓ **STANDARDIZED RESISTANCE Vs. TEMPERATURE** — The resistance - Temperature characteristics meet "AN" specifications from —70°C to +200°C, and have been extended to 300°C.

✓ **ACCEPTED AS STANDARD BY LEADING AIRFRAME MANUFACTURERS** —

These Bulbs are used as standard equipment on the following Aircraft:—

BOEING STRATOCRUISER 377

CONSOLIDATED 240

DOUGLAS DC-6

LOCKHEED CONSTELLATION 49

MARTIN 202 and 303

REPUBLIC RAINBOW RC-2

THE LEWIS ENGINEERING CO.

Specialists in Engine Temperature Measurements

• NAUGATUCK, CONNECTICUT. •

• POTENTIOMETERS • • • • • • SELECTOR SWITCHES • • • • • • • • • THERMOCOUPLES •
• PYROMETERS • • • • • • RESISTANCE THERMOMETERS • • • PROTECTION TUBES •

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 487.

Inclinometer Tube for Prime-relay Functions

New "Y-Type Position Convectron" is a Y-shaped gas-filled non-emission tube capable of giving an appreciable signal relative to its position about vertical. Fig. 1 shows it one-half size. Signal polarity (or phase if a-c. operation) obeys whether displacement is to left or right of null, so that tube can be used in control systems, servomechanisms, self-balancing instruments, etc. Signal strength depends upon rate at which gas convection currents leave heated filament and rise vertically, and upon angle that filament makes with vertical. Tube's "time-constant" is approx. 0.1 sec. Signal is approx. 50 mv. per degree at null. A-c. noise level 1 to 5 mv. (d-c., zero). Since tube has no moving parts and signal is obtained directly without oscillation, tube offers solution of problems inherent in older methods of obtaining vertical reference. With d-c. operation, ultimate sensitivity is one second of arc if certain precautions are taken. — *Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.*

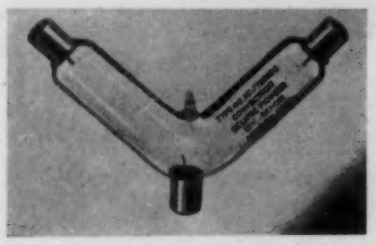


Fig. 1

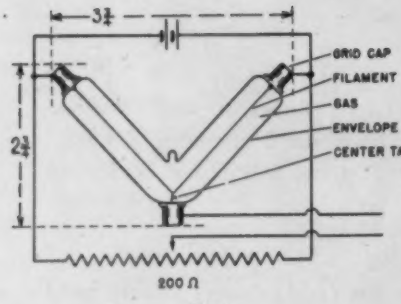
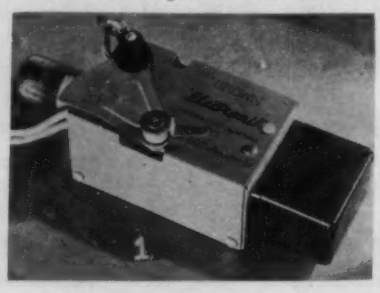


Fig. 2

Please mention number 501 when filling out card

Adjustable-mode Control Unit

New "Electr-O-Vane" unit is for use with temperature and pressure instruments. Announcement states: "Electronic principles of continuous control have been developed for the first time in the industrial thermometer and pressure gage field . . . some processes heretofore controllable only with electronic potentiometers can now employ the new instrument to obtain wanted results." Principle: "when a metal vane is interposed between two oscillator coils, state of oscillation can be made to change or stop in an electronic circuit . . . to operate a load relay." Oscillator coils are molded in Bakelite and are moisture-proof. Unit is self-contained, easily removed, unaffected by dust or dirt.—*Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Penna.*



TYPE OF CONTROL ACTION	NUMBER OF CONTROL UNITS	CONTACT ACTION	CONTACT LOAD RATING 115 VOLTS
"ON-OFF" CONTROL ON SINGLE-PEN INSTRUMENT	ONE	A — B; OFF. 300°F. 600°F.	30 AMPS.
TWO POSITION CONTROL ON SINGLE-PEN INSTRUMENT*	ONE	A — B; OFF. 300°F. 600°F.	6 AMPS.
THREE-POSITION CONTROL ON SINGLE-PEN INSTRUMENT* (ONE INDEX)	TWO	A — C — B; OFF. 600°F.	6 AMPS.
THREE POSITION CONTROL ON SINGLE-PEN INSTRUMENT (TWO INDICES)	TWO	A — C — B; OFF. 600°F.	6 AMPS.
TWO POSITION DUAL CONTROL ON TWO-PEN INSTRUMENT (TWO INDICES)	TWO	A — B; OFF. 300°F. 600°F.	6 AMPS.

Fig. 2. *ALSO AVAILABLE ON TWO-PEN INSTRUMENT WITH CONTROL ON ONE PEN

Please mention number 502 when filling out card

Gas Regulator and Valve

New "No. V482" and "V882" control for domestic gas burners combines a magnetic gas valve with a weight and spring-loaded combination regulator. Diaphragm is of type N synthetic buna with a nylon insert. Device will be available in ½" and ¾" sizes, will carry a pressure rating of 8 oz./in.², will be adaptable for use with butane, propane, sulphur gases, as well as natural gas. — *Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

Please mention number 504 when filling out card

Lens-testing Projector

New testing projector is especially designed for final inspection of completed and mounted photographic lenses. A target, imprinted with a series of minute replicas of a specially-designed testing chart, provides image which is projected through lens being tested and onto screen. Each chart is so placed on target that entire image field may be examined for all types of abberrations. By remote control, one operator standing near screen moves lens back and forth within instrument until image is in exact focus; and determines whether lens meets required standards. A second operator interchanges lenses to be tested and checks uniformity of back focal length. Targets for testing lenses of long focal lengths may be readily interchanged in a rotatable metal holder. Positions of all component parts of projector may be independently adjusted for maximum performance.—*Bausch & Lomb Optical Co., 625 St. Paul St., Rochester 2, N. Y.*

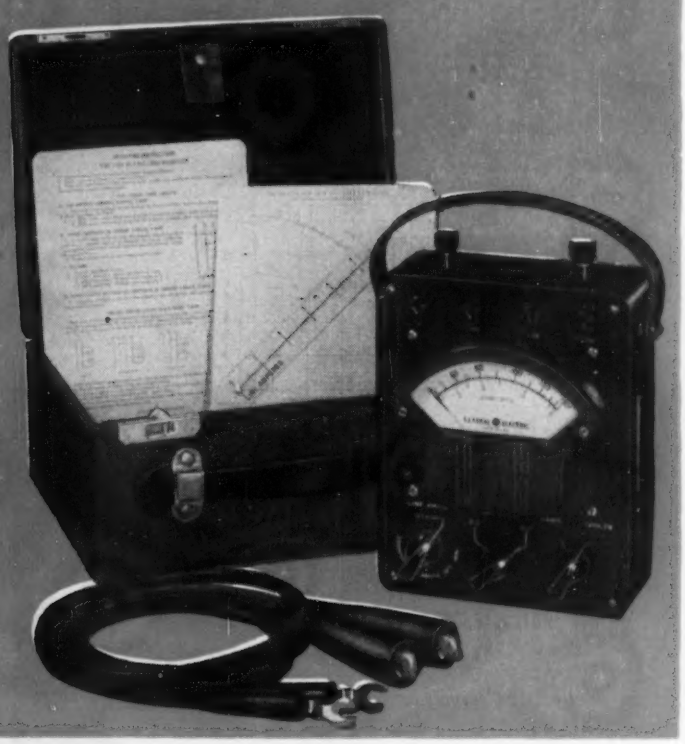
Please mention number 503 when filling out card

Laminated Materials Bonding Tester

New "Aminco Bondimeter" is for detecting faulty bonding of flat laminated materials such as plywood veneers, metal-plastic "sandwiches" and laminated plastics in research, production testing, and inspection. It consists of a hollow aluminum cylinder with a transparent plastic window at top and an open bottom, forming an inverted cup. Inside cylinder is a dial gage with its stem resting against surface of test specimen. A valve automatically maintains a constant difference between pressures inside and outside cup. In operation, "Bondimeter" is placed on surface of speci

Presenting

THE NEW A-C LOAD VISUALIZER



A COMPACT, PORTABLE SET FOR MEASURING A-C POWER

Here's a new indicating device created by General Electric to meet industry's need for a small, lightweight, low-cost analyzer. Employing an advanced principle of instrument design, it permits all readings to be made on a single scale. Easy to operate and having a wide range of usefulness, this versatile instrument requires only a few simple, convenient connections.

5 INSTRUMENTS IN ONE

Besides serving as a standard 0-2.5/5-amp ammeter and a 0-150/300/600-v voltmeter—or with conventional instrument transformers to extend the range—this instrument can be used, with the aid of the calculator provided, to determine quickly and easily watts, vars, and power factor for load surveys, induction motor tests, reactive-power studies, and power-factor improvement programs.

This handy instrument comes complete with instruction card, calculator, and flexible voltage leads, all enclosed in a sturdy carrying case. Total weight only five pounds. For additional information, write for Bulletin GEA-4784. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

PRICE $97.50

THIS LINE OF GENERAL ELECTRIC PORTABLES INCLUDES:

CF — INKLESS RECORDER

INK RECORDER — CD

AK-1 — A-C HOOK-ON VOLT-AMMETER

A-C VOLT-WATTMETER — AP-9

GENERAL ELECTRIC

CLIP AND MAIL THIS COUPON TODAY

Yes, I need one of your new A-C Load Visualizer sets immediately. Enclosed is my order, with check for $97.50. Ship express collect.

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What's YOUR special battery problem?

Here's another tough one Burgess engineers solved

THE PROBLEM

To build—to rigid physical specifications—a battery of 400 volts for a constantly intermittent drain 24 hours a day and to have a useful life of 1 year.

THE SOLUTION

A compact ruggedly constructed unit 3⅛" x 3⅛" x 6⅛" equipped with insulated terminals and with an initial voltage of 400. Designed with the type of cells necessary to deliver this continuous service 24 hours per day for one year.

The Complete Burgess Facility
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. . . is at your disposal to provide the battery you need in the quantity you need . . . large or small.

Send for this free check-sheet . . . it enables you to easily and quickly provide Burgess engineers with all information important to design of a battery for your special requirements.

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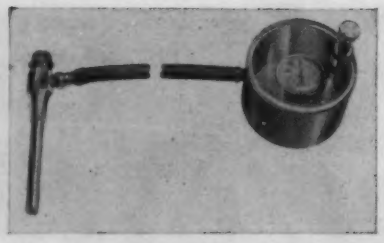
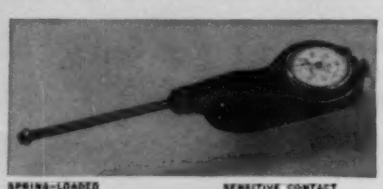


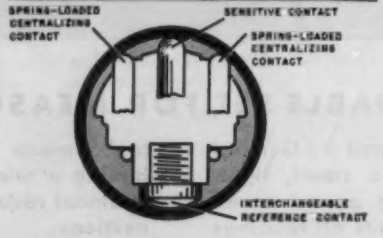
men; cup is evacuated by an aspirator; partial vacuum forces specimen into cup; a well-bonded laminated material deflects slightly as shown on dial gage. In a faulty bonding, however, air trapped between laminations forces laminations apart and into cup; large deflection indicates poor bonding. — *American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.*

Please mention number 505 when filling out card

Small-hole Indicating Gage

New "Model 1204 Small Hole Gage" reads I.D's in ten-thousandths between 0.250" and 0.500", is of self-centralizing



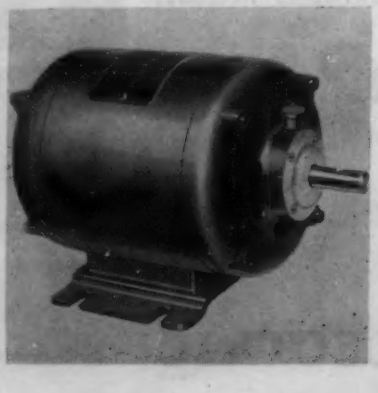


design, employs fourteen interchangeable extensions to cover full range from ¼" to ½", explores any hole within its capacity to a maximum depth of 2¼", revealing diameter and also roundness, taper, bellmouth, and other hole inaccuracies. — *Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

Please mention number 506 when filling out card

Instrument Motors

New "29 Size" synchronous capacitor-type motors can be supplied in ratings of 1/100, 1/75 and 1/50 hp., 1800 r.p.m., 115-volts 60-cycle. Vibration-free performance is claimed. All ratings are ventilated. Motors can be supplied with either permanently-lubricated

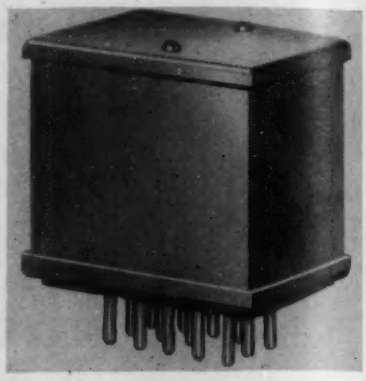


sealed and shielded ball bearings, or large self-lubricating bronze sleeve bearings which withstand heavy or vibrating loads. New "29 Size" is normally supplied as a balanced capacitor start and run motor—essentially a two-phase motor with a uniformly-rotating magnetic field. — *Cyclohm Motor Corp., 5-17 46th Road, Long Island City 1, N. Y.*

Please mention number 507 when filling out card

Rheostatic Voltage Regulator

New "Regohm" is a direct-acting rheostatic type of automatic voltage regulator for a wide variety of appli-

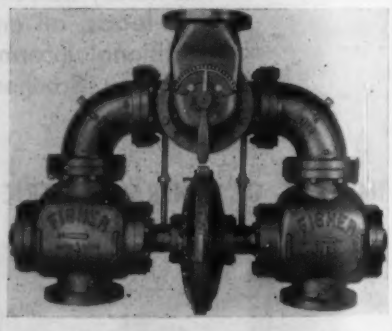


cations. Primary element is a d-c. solenoid coil consuming 1 watt (about 5 watts with voltage-dropping resistor), sensitivity ± 2%. There are ten steps of control resistance at up to 8 watts per step with 80 watts total. Inherent resistance of contacts is 0.1 ohm; maximum current 4 amps. Response is within two cycles. An easily-adjusted dash pot provides stability. Regulator weighs 7 oz., measures 1 3/8" × 1 15/16" × 1 3/4" high (+ 7/16" length of pins), operates in any position, withstands vibration and shock.—*Electric Regulator Corp., 1915 Park Ave., New York 35, N. Y.*

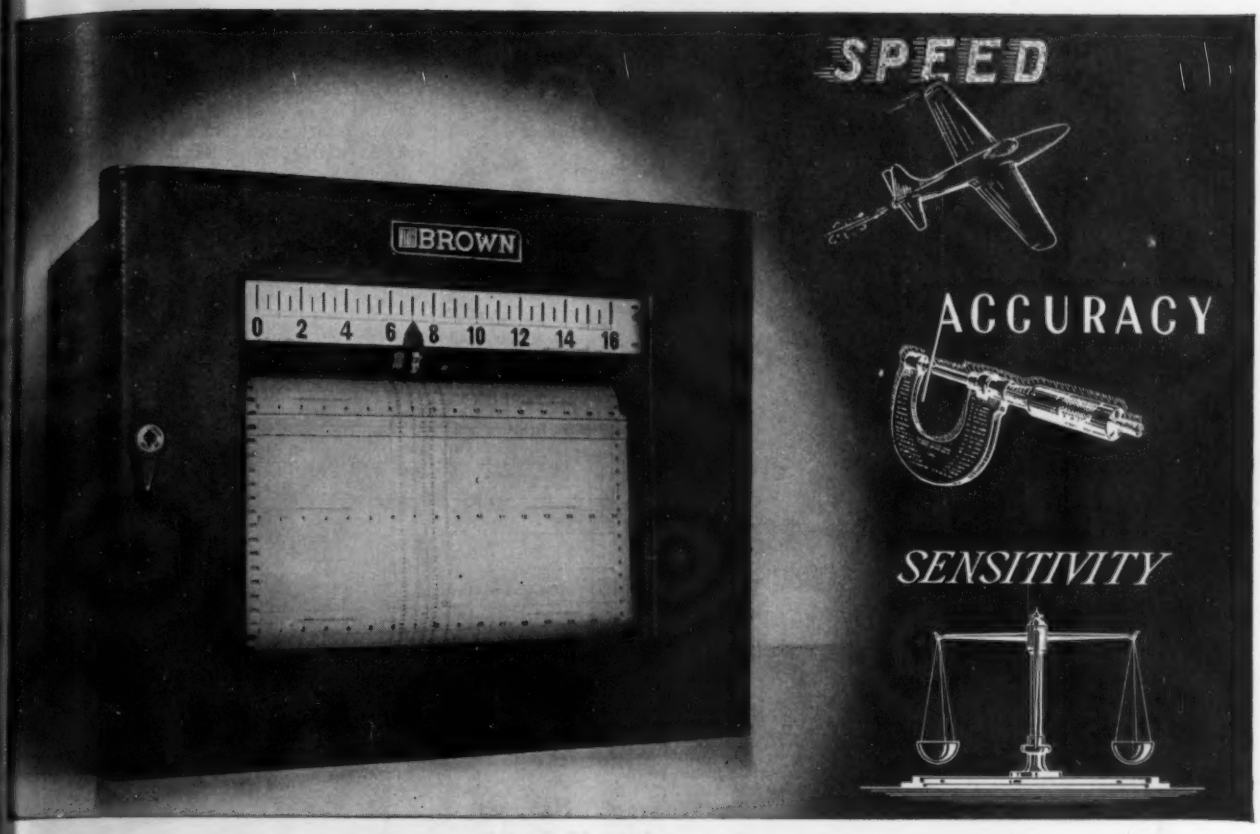
Please mention number 508 when filling out card

Automatic Blending Valve

New "Type 430 Blending Valve" automatically blends two fluids in accurate desired proportion, is particularly de-



signed for processes in petroleum and allied industries. Fluids from two different storage tanks are accurately blended, even though pump or inlet pressures vary. Liquids to be blended are brought to central pressure-equalizing valve, which maintains equal pressure at both inlets of proportioning valve. New device eliminates the necessity of measuring given quantities and



ElectroniK Potentiometers Put THEORIES into PRACTICE

IN the past, advanced processing *theory* developed in the laboratory was handicapped in plant *practice* by the lack of really adequate pyrometer equipment. The Brown ElectroniK Potentiometer hurdled this barrier. Unparalleled accuracy, sensitivity and speed of response have enabled process engineers to *put theories into practice with laboratory accuracy.*

Based on an enviable six year performance record, this instrument is being proclaimed, "The greatest advance in industrial instrumentation since World War I".

ElectroniK Potentiometers are supplied in a wide selection of models both with strip and circular charts and in a large variety of electric and air-operated control forms to fulfill the requirements of any process. Now they are available for 25, as well as 50 or 60 cycle operation.

The Brown ElectroniK Multiple Record High Speed Potentiometer, illustrated above, will record 2 to 16 different temperatures with chart speeds up to 120 inches per hour. The pointer travels full scale in 4½ seconds—balances immediately—prints immediately—then switches to the next point. Minimum printing time between closely spaced points is one second; maximum time between temperature extremes is five seconds.

•

Write today for Catalog 15-8. THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Company,* 4482 Wayne Avenue, Philadelphia 44, Pa. Offices in all principal cities.

TORONTO, CANADA — LONDON, ENGLAND
AMSTERDAM, HOLLAND — STOCKHOLM, SWEDEN
BRUSSELS, BELGIUM

BROWN ElectroniK POTENTIOMETERS

HELICOID SCORES AGAIN!

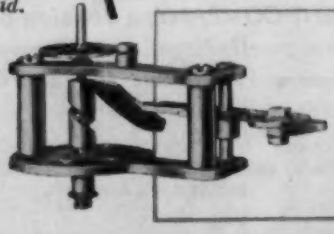
• The new ACALOY case is a high-compression molded aluminum alloy. Treated by a patented process to prevent corrosion. Durable baked-on finish. Withstands 1200 hours salt spray test.

Weather-proof. Neoprene sealing gasket. 18-8 stainless steel snap ring. Greater strength—less weight. It's another Helicoid exclusive.

With back flange for wall mounting, or without flange for stem mounting. Safety blow-out discs optional.

Specify Helicoid gages in the new ACALOY case. They will reduce your maintenance expense. . . . the Helicoid movement, with no gear teeth to wear out, lasts many times longer.

Send for the new catalog that tells the complete story of Helicoid.



Only Helicoid pressure gages have the Helicoid movement.

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

TRADE MARK

batch agitation, reducing blending process expense. Pointer and "0-100" scale device afford a simple method of accurately controlling percentage of inlet fluids to be blended. Capacities: 30 to 900 g.p.m.; sizes: 3″ and 6″ only; pressure rating: 3″, 100 lbs./in.^{2}; 6″, 150 lbs./in.^{2}.—*Fisher Governor Co., Marshalltown, Iowa.*

Please mention number 509 when filling out card

Automatic Inspector-classifier for Pistons

New "Airlectric Multicheck" combines automatic inspections of critical dimensions of automotive pistons and

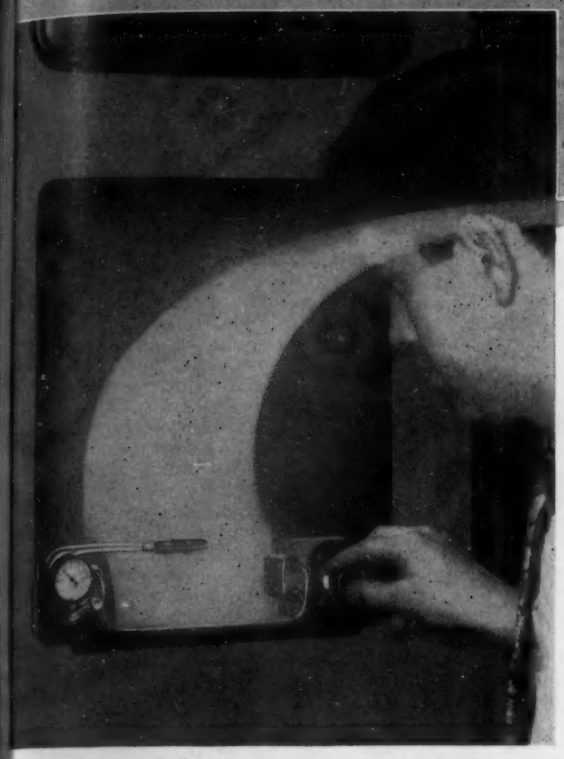
eight classifications. Operator merely loads and unloads pistons. Rate of inspection and selection is between 500 and 700 pistons per hour. Simultaneous automatic measurements are: average diameter of pin holes at each of two bearings, diameters of four ring grooves, widths of five ring grooves and diameter of bottom skirt—a total of twelve. In addition, three classifications of pistons are automatically made on basis of average diameter of pin hole; and five classifications on basis of bottom skirt diameter. Classes are automatically color-stamped—*The Sheffield Corp., Dayton 1, Ohio.*

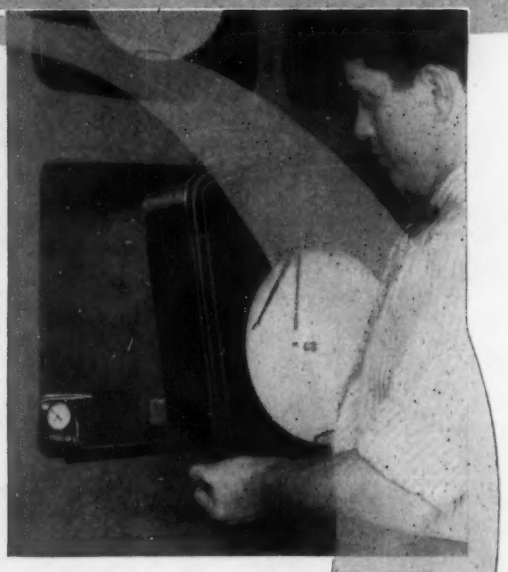
Please mention number 510 when filling out card

Hand Tachometer

New "Type 25C" hand tachometer is similar in appearance to "Type 25A" described in *Instruments* Dec. 1945, page 922, and "Type 25B" *(Instruments,* Nov. 1946 page 694) but has higher accuracy: 0.5% or better and has a single-speed measuring range of 110 to 210 rpm. full scale. Other speed

THIS CONTROLLER IS EVEN EMERGENCY-PROOFED



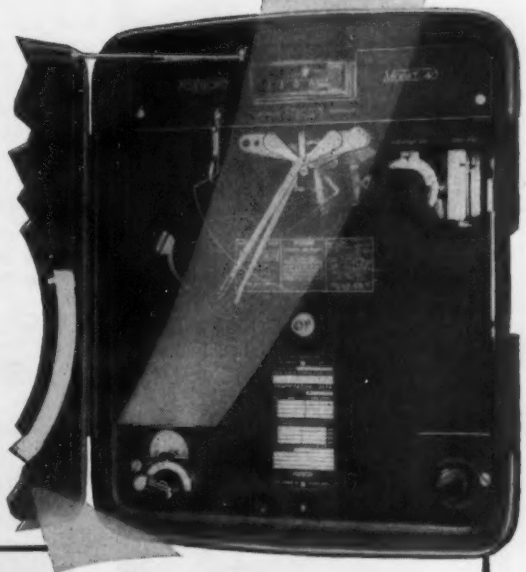


New M-40 has detachable unit that gives independent manual control, "bumpless" transfers

IMPROVEMENTS designed into the new Foxboro M-40 Controller don't stop at laboratory refinements. In every last detail, this instrument is engineered to improve, not only *end results* of processes, but also convenience for the operator.

An outstanding example is the exclusive Manual Control Sub-Panel which is a detachable sub-assembly. It permits permanent hook-up of all panel connections with full manual control facilities *before the complete instrument is mounted* . . . and may be left on the panel to carry on manual control in emergencies, when the Controller is removed.

The "heart" of this unique Sub-Panel is a completely redesigned 4-position Transfer Switch that provides instant switching without any tricky equalizing of gauge readings . . . without slightest "bumping" of the valves.



Detailed description of this and many other radically improved features of the new M-40 Controller are available in Bulletin 381. Write **The Foxboro Company, 46 Neponset Ave., Foxboro, Mass., U. S. A.**

4-Position Switching on Sub-Panel

1 AUTOMATIC POSITION—for normal operation.

2 MANUAL POSITION—for convenience in starting-up, or any emergency requiring manual control. Provides instant return to automatic without "bumping" the process.

3 SERVICE POSITION—permits mechanical servicing, or even complete removal of Controller, with manual control maintained.

4 TEST POSITION—permits complete check of controller mechanism without disturbing manual control.

FOXBORO Reg. U. S. Pat. Off.

M-40 CONTROLLER

The Only Controller with *Permaligned* Construction

PHOTOGRAPHIC EQUIPMENT
for your
RESEARCH AND LABORATORY DEPARTMENTS

EVERYTHING YOU NEED
CAMERAS • LENSES • ENLARGERS
and DARK ROOM EQUIPMENT

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321 So. Wabash 155 Chicago 4, Ill., U.S.A.

ranges from 10 up to 10,000 rpm. are available where highest speed is about twice lowest speed to be measured.— *Metron Instrument Co., 432 Lincoln St., Denver 9, Col.*

Please mention number 511 when filling out card

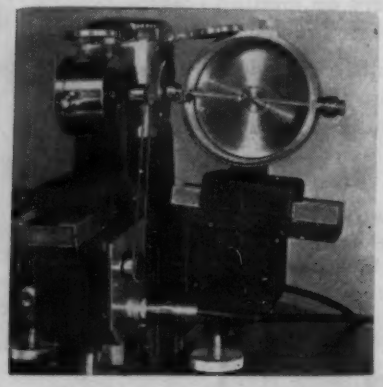
Instrument for Diagnosing Glaucoma

New "Allen Gonioscope" weighs less than 0.1 ounce, permits routine gonioscope examination of the eye, is especially valuable in observing glaucoma but permits other clinical studies such as trauma, inflammatory processes, pigmentary anomalies, etc. Instrument's precision optical prism, held against the eye itself, re-directs light and enables diagnostician, aided by a slit lamp microscope, to see "around" cornea, and into the channels where disease occurs. Prism, mounted in a small plastic speculum, is rotatable to permit examining entire corneal area.— *Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 8, N. Y.*

Please mention number 512 when filling out card

X-ray Diffraction Camera

New high-intensity high-resolution powder camera is said to incorporate advanced features, among which are: (1) slit system said to produce remarkably clean film patterns and reduce exposure time; (2) precise collimator and beam tube alignment; (3) light-tight cover design; (4) universal saddle which adapts camera for use on existing types of x-ray diffraction apparatus made by Philips or other manufacturers. This mount employs new track having rectangular profile with reference and bearing surfaces hard chrome plated to minimize wear and aid in precise repositioning. Mechanical design facilitates rapid vertical translation and pivoting of track, making possible quick and easy camera alignment. A synchronous drive motor (1 rpm.) is incorporated in new mount assembly. — *North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.*



Please mention number 513 when filling out card

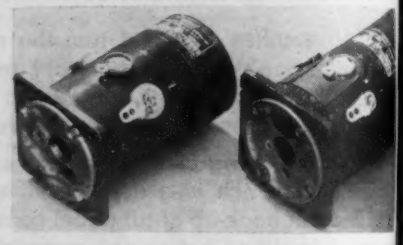
Radar Altimeter Switch

New "Type AVA-68" electrically-operated coaxial-transfer d-p. d-t. switch, said to be the first one of its kind to be produced for use with radar type altimeters, makes possible the use of a single pair of antennas for operation of two radar altimeters. It can be operated from any remote position in aircraft; a two-wire cable connects it to a toggle switch in cockpit. A flip of toggle switch causes the rotor mechanism in transfer switch to make electrical connection between antennas and desired altimeter. Simultaneously, unused altimeter is turned off automatically. UHF portions of switch contacts are of a snap-action, wiping type with corrosion-free surfaces. New switch can also be used for any other electronic equipment which employs a 52-ohm coaxial line. — *Engineering Products Dept., Victor Div., Radio Corp. of America, Camden, N. J.*

Please mention number 514 when filling out card

Servomotors

New servomotors, of either ½" or 1" corestack, are designed for thyratron control operation from 115-volt 60- or 400-cycle a.c. Both feature 72-to-1 built-in gear reduction, armature resistance of approx. 100 ohms, and field excitation of 28-volt d-c. Torque output at approx. 150 rpm. of the ½" type is 60 inch-ounce; 1" type, 150 inch-ounce. Field current 0.15 and 0.23 ampere, respectively. Backlash of gear box is "very low." Overall dimensions, 2" × 2" × 3" and 2" × 2" × 3½". Weight including gear train, < 1 lb. New servomotors are for use in measuring instruments, proportional follow-up systems, computing mechanisms, stabilization systems, etc. Both are available in limited quantities, or on consignment. — *Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.*



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Electric Heater

New electric heater consists of various metals completely embedded in Pyrex or silica glass. Wire being in intimate contact with the glass over its entire surface, heat transfer is excel-

New Condensed Catalog

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- CONTROL SYSTEMS
- MILLIVOLTMETERS
- POTENTIOMETERS
- RESISTANCE THERMOMETERS
- INPUT CONTROLLERS
- INDICATORS
- COMBUSTION SAFEGUARDS
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The complete story of Wheelco Control Systems is told in this new, twenty page three-color catalog. It explains why Wheelco instrumentation systems give more accurate indication and control of your manufacturing process.

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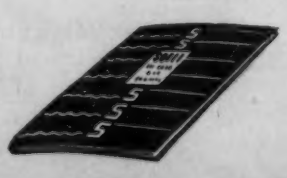
833 W. Harrison St., Chicago 7, Ill.

WHEELCO *Electronic* CONTROLS

Speed · Simplicity · Serviceability

- **The Sorensen NOBATRON provides a new source of DC voltages regulated at currents previously available only with batteries.**
- **Six standard NOBATRON models operate on a 95-125 volt AC source of 50 to 60 cycles and provide currents of 5, 10, and 15 amperes at output voltages of 6, 12, or 28.**
- **Ideally suited for critical applications where constant DC voltages and high currents are required, the NOBATRON maintains a regulation accuracy of ½ of 1%, RMS of 1% and has a recovery time of 1/5 of a second.**

● *Investigate the many advantages of Sorensen regulators applied to your unit. Write today for your copy of the new complete Sorensen catalog, S-I. It is filled with schematic drawings, performance curves, photos, and contains in detail, "Principles of Operations."*



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STAMFORD, CONNECTICUT

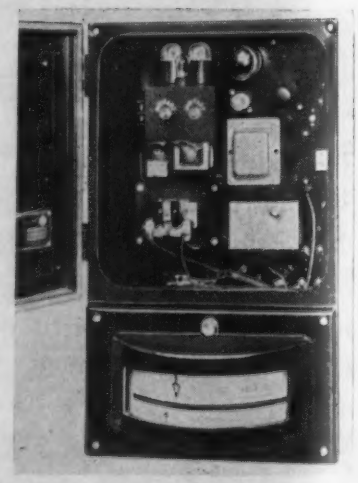
A LINE OF STANDARD REGULATORS FOR LOAD RANGES UP TO 30 KVA.
SPECIAL UNITS DESIGNED TO FIT YOUR UNUSUAL APPLICATIONS.

lent. In water, heat output is equivalent to 125 watts/in². Heavy metal coatings can be applied to units in various ways. Units can also be inserted into metal tubing and intervening space filled with lead or other metal, so that rate of heat transfer is maintained. Consequently, new units require much less space than conventional ones. Where high resistance to heat shock, corrosion or high temperatures is required silica glass units are recommended. Units can be supplied with vapor-proof rubber-covered connections for service in corrosive atmospheres. They can also be supplied with special terminals as required for various applications. Units are produced for 600 watts at 120 volts and 1200 watts at 240 volts. (Larger or smaller units special). The 600-watt unit has a ½″ nominal diameter and immersed portion is 4″ long; 1200 watt unit ½″ nom. dia. 7″ immersion. Overall length of unit can be varied to suit mountings. Heater wire being completely embedded in glass and rigidly held in place, it is thoroughly protected from corrosion, oxidation or breakage due to expansion or contraction. Pyrex heaters can be safely used up to a heated temperature of 1000°F.; silica glass units 1600°F. and higher. Applications include injection molding machines, molding press platens and pewter or lead melting pots. Bare glass unit being corrosive proof is ideally suited for heating liquids in laboratories, hospitals, etc.; for fractionating or other types of stills; air heaters; built-in uses in molding equipment, flash boilers, water heaters, etc.; also as an excellent infrared radiator.—*Thermolettor Products, 95 Broad St., New York 4, N. Y.*

Please mention number 516 when filling out card

Automatic Temperature Controller

New "Xactline Capacitrol" combines features of Claud S. Gordon Co.'s "Xactline Control Unit" and Wheelco



Instrument Co.'s "Capacitrol." Principal features of "Xactline" are said to be: "anticipating" factor which holds temperature tolerances as close as ± 1/5°F. and power "on-off" cycles as short as 3 seconds, positive electrical action, simple adjustment for wide-range control requirements. For "Capacitrol": electronic control prin-

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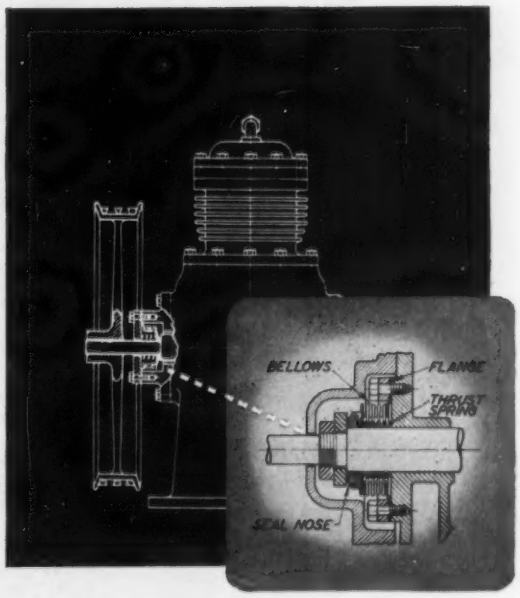
IF YOU'RE LOOKING for a *sure* way to seal a rotating shaft against seepage of gas or liquid, a Sylphon Seal is the quick, easy, low-cost answer to your problem.

Sylphon Shaft Seals are engineered on order for specific applications, in a wide range of sizes—for delicate, tiny instruments up to large marine and industrial installations. Sylphon Seals withstand heavy pressures up to hundreds of pounds . . . hold firmly . . . are easily mounted . . . seal shafts gas- or liquid-tight.

Successfully used in a wide variety of applications, such as compressors, pumps, washing machines, hydraulic transmissions, etc. Find out how Sylphon Seals can help *you*. Write today for informative Catalog JE-825 that gives you complete details.



Typical use of a Sylphon Seal in a refrigerator compressor. Careful study given to applications requiring special designs.

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Bradley rectifiers are designed to give you trouble-free service. Their electrical characteristics remain stable indefinitely. When operated within normal rating, their life is unlimited.

Send for curves showing current, voltage, resistance and temperature characteristics of Bradley copper oxide rectifiers.

Illustrated literature, available on request, shows more models of copper oxide rectifiers, plus a line of selenium rectifiers and photocells. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

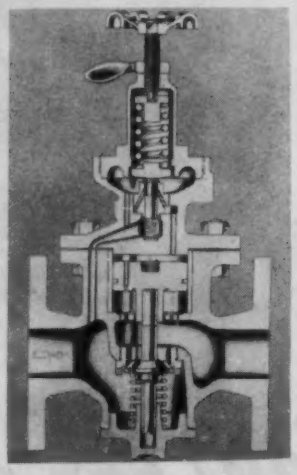
82 Meadow St. New Haven 10, Conn.

ciple, instantaneous control action, direct-reading indicating scale, separately-enclosed measuring instrument, and interchangeable unit construction.—*Claude S. Gordon Company, 3000 S. Wallace Street, Chicago 16, Ill.*

Please mention number 517 when filling out card

Overflow Valve

New "Class UL" throttling type unloading valve for use with steam, air or gas is applicable wherever a



throttling type regulating valve is required to maintain a constant inlet pressure by relieving the excess to a lower pressure system. Smooth throttling control during entire cycle of operation, and with quick action under sudden pressure variations, are claimed. Construction features include renewable wearing parts, hardened stainless steel main and controlling valves, corrosion-resistant piston rings, phosphor bronze diaphragm. Available in sizes from ½" to 4"; for inlet pressures from 25 to 300 lbs./in.^{2}, inlet temperature to 550°F. and pressure difference not less than 15 lbs./in.^{2}.—*Leslie Co., 225 Delafield Avenue, yndhurst, N. J.*

Please mention number 518 when filling out card

Underground Gas-leak Locator

"M-5 Vapotester" is a self-contained portable gas detector operating on standard flashlight batteries, for locating leaks in underground gas mains and service lines. It quickly reads concentrations up to 100% gas on a three-range scale, "A," "B," and "C." Illustration shows switch at right lettered "C," "CHECK" and "A-B." When testing bar holes, switch is first positioned at "C" to read on "C" scale (higher concentrations). If there is no reading on "B" scale, dilution valve is closed and "A" scale readings are taken. It is stated that highest point of concentration, as taken from log of bar hole readings, is point nearest gas leak, thus preventing loss of time and labor in unnecessary digging.—*Davis Emergency Equipment Co., Inc., 80 Halleck St., Newark 4, N. J.*

Please mention number 519 when filling out card

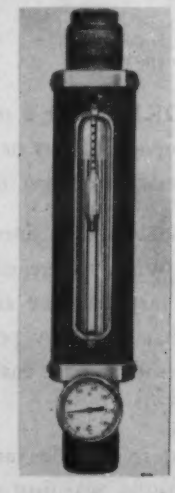
Pyrosensitive Recorder Paper

New "Pyrochrome" is a heat-sensitive, chemically-treated paper for direct-recording instruments. Coating is white, non-granular, abrasion-resistant, unchanged by direct sunlight, unaffected by moisture, electrically non-conductive. Record is produced by an artificial-sapphire stylus heated by a Nichrome wire (2.5 to 3.5 volts required). Various stylus assemblies are available, all with unexposed wires, some with internal wires, weights 15 to 25 milligrams. Unprinted paper is available in all sizes from 2½" to 12", spooled on cores with ½" or 1" inside diam.; printed paper is slit to size and spooled in lengths from 100 ft. to 1000 ft.; normally packaged in lots of 100 spools.—*Pyro-Sensitive Paper Div., Polychrome Corp., 2 Ashburton Ave., Yonkers 2, N. Y.*

Please mention number 520 when filling out card

Continuous Specific Gravity Indicator

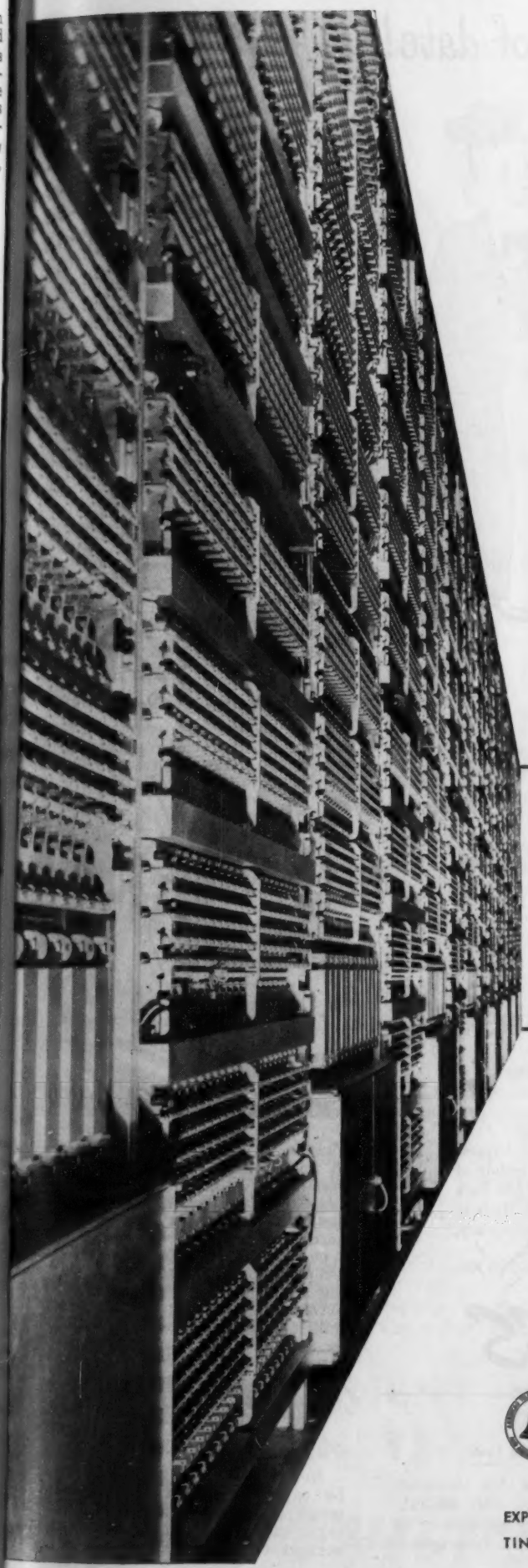
New specific gravity indicator is designed for continuous indication of liquid specific gravity in closed piping systems, particularly in distillation work and in connection with all process systems in which draining of sample batches is considered tedious or hazardous. Instrument is said to be sturdily constructed to withstand very heavy line strain, but at the same time attractive in appearance. Suitable brackets, bezels and lighting accessories are available for adapting instrument for front or rear panel mounting. Standard construction includes carbon steel, bronze, stainless steel or Hastelloy. Needle control valves, thermometers and hydrometers are built into unit. High visibility of hydrometer and thermometer scales is claimed.—*Fischer & Porter Co., Dep't 5C-B, Hatboro, Pa.*



Please mention number 521 when filling out card

Course-plotting Tape for Aircraft Navigation

New "Grimes Navigation Tape" is transparent, ½" wide, is applied easily to aeronautical charts for course plotting, has a line down center to show pilot's course. Cross-lines and numbers indicate miles flown from starting point and in reverse for return trip. Two types: for Sectional Charts (scale of 1 to 500,000) and for World Charts (1 to 1,000,000). Tape adheres



WHEN you spin the dial of the latest type of telephone system—known as "common control switching"—you order into action a giant nervous system. It sends electrical impulses through an intricate maze of circuits: more than 10,000 contacts can be opened or closed in a single dial call.

This system takes your order, remembers it, translates it into its own electrical language, throws out sensitive "feelers" to find a through route, plans how to make the connections, makes them, puts through the call—and, if the preferred paths are busy, finds an alternate route to take the call.

The complex art of telephone switching is brought to a high state of development at Bell Laboratories to serve the Bell System. Some day through "common control switching" a dial in San Francisco may set up a connection through to a subscriber in New York.

■

Left: Backstage on your dial telephone call—some equipment in a typical "common control switching" office.

Bell Telephone Laboratories

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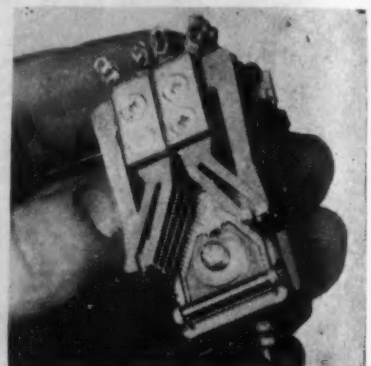
to chart; is not obliterated for future use. Many courses may be plotted on the same chart. Tape strengthens chart, which folds readily. Each roll is packed in metal container, enough tape per roll to plot 2,000 miles of flight with Sectional Chart tape and 4,000 miles with World Chart tape.—*Grimes Mfg. Co., Urbana, Ohio.*

Please mention number 522 when filling out card

Twin-contact D-c. Relay

New "Type J" d-c. relay said to combine best features of conventional telephone-type relay with small size and light weight of aircraft relays is 2¼" long and weighs 2½ oz. Feature is use of independent twin contacts whereby possibility of contact failure is minimized. Palladium-material contacts, of dome-and-disk type, are rated 4 amperes, 150 watts. Other feature: hinge type armature bearing of entirely new design providing largest possible bearing surface. "Type J" is designed for extremely fast operation—one to two milliseconds. Maximum of ten springs on a single-arm relay, 20 on a double-arm relay.—*C. P. Clare Co., 4719 West Sunnyside Ave., Chicago 30, Illinois.*



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Midget Relay

New "Series 600" relay is claimed to be capable of performance equal to many larger and more expensive relays; can be furnished with numerous contact switch combinations up to and

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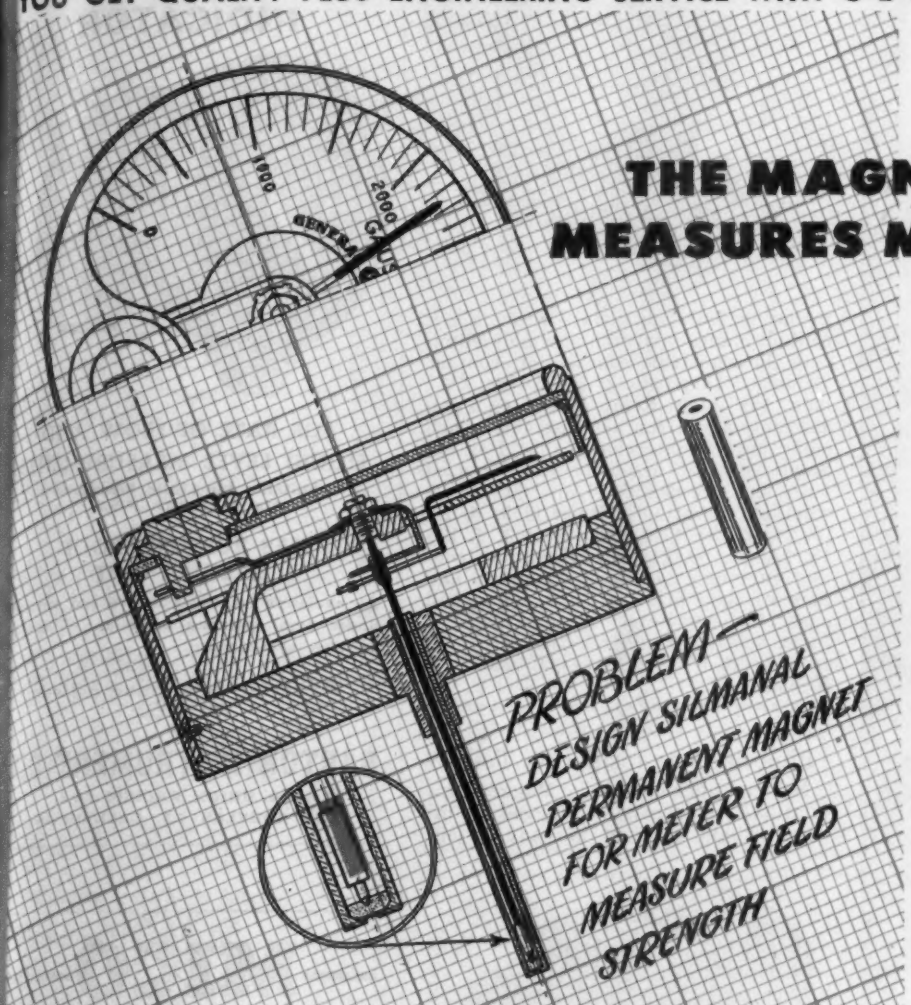
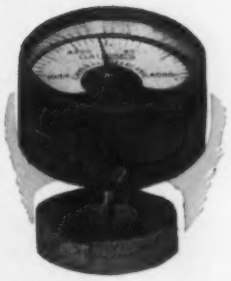


THE MAGNET THAT MEASURES MAGNETISM



A tiny SILMANAL cylinder magnetized along a diameter is the heart of the G-E gauss meter. When the probe is placed in the field of a permanent magnet or a d-c electromagnet, the SILMANAL magnet on the shaft tends to line up with the flux. Flux density is measured by rotating the instrument until the pointer reaches its highest reading. This occurs when the probe-magnet flux is at right angles to the flux being investigated. The pointer when at zero scale position indicates flux direction.

Augmenting the many grades of sintered and cast ALNICO permanent magnets, four additional General Electric alloys —SILMANAL, CUNIFE, CUNICO, and VECTOLITE —now greatly extend magnet design possibilities.

So ductile and malleable that they can be machined as readily as soft steel, SILMANAL, CUNIFE and CUNICO possess outstanding properties suitable for a wide range of special applications. SILMANAL is particularly adapted to devices used in the presence of severe demagnetizing influences.

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Let us help you with your magnet application problems. General Electric Engineers, backed by years of research and magnet design experience, are at your service. *Metallurgy Division, Chemical Department, General Electric Co., Pittsfield, Mass.*

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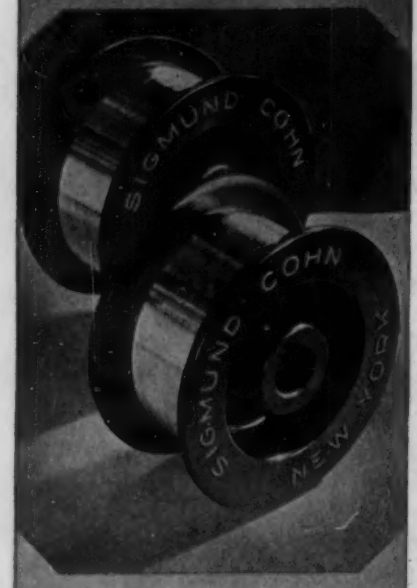

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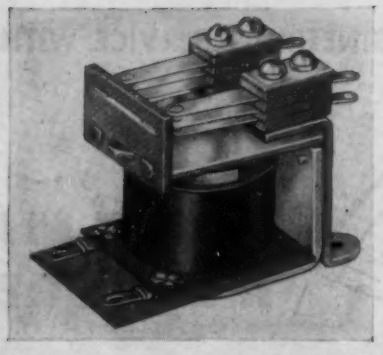

including four-pole double-throw. Short contact blades in switch assembly eliminate intermittent contact or contact "bounce." Dimensions: 1⅛" wide, 2⅛" long, 1½" high. Relay comprises a coil assembly and a contact assembly. Each basic part is interchangeable. For example, contact assembly can be used with any "Series 600" or "605" coils whether operating voltage is 3, 6, 12, 18, 24, 32, 50, 115, 230 a-c. or 3, 6, 12; 18, 24, 32, 50, 110 d.c. Maximum contact current capacity is 8 amperes and power consumption is 6 v.a. Relay will pass Underwriters' specifications. — *Dept. 600, Guardian Electric Mfg. Co., 1638 West Walnut Street, Chicago 12, Illinois.*

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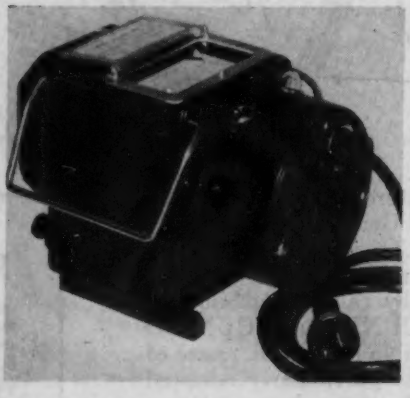
Plug-in Type Insulation Tester

New rectifier-operated "Megger" Insulation Tester can be plugged in instead of hand cranked, is ready for op-



eration by connecting to 115 volts a.c., is especially useful where a large number of tests are to be made at one time or where an individual test is continued for many minutes (dielectric absorption tests where careful observations of insulation resistance are made over a period of ten or more minutes). Power pack consists of a constant-potential step-up transformer and selenium rectifier giving a constant d-c. test voltage. "Megger" ohmmeter covers a wide range and is independent of applied voltage. Ratings are available up to 2000 megohms and 1000 volts.—*James G. Biddle Co., 1211 Arch St., Philadelphia 7, Penna.*

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Carbon Monoxide Indicator

New "N.B.S. Carbon Monoxide Indicator" is authorized commercial model of device developed and manufactured during the war by the National Bureau

Differential Pressure INDICATOR

FOR RATE OF FLOW AND LIQUID LEVEL MEASUREMENTS

Suitable for Static Pressures Up to 3,000 P.S.I.

HAS RUPTURE-PROOF BELLOWS UNIT

An exclusive feature. Sensitive and accurate under high operating pressures. Withstands extreme over-ranging.

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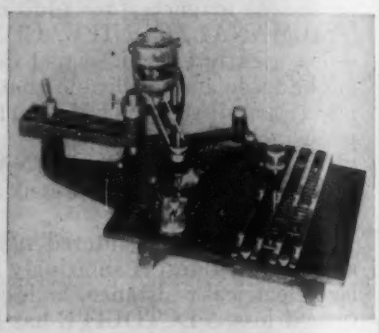

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Attachments adapt it to small or large work on flat or curved surfaces.

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Widely used for production as well as occasional engraving.

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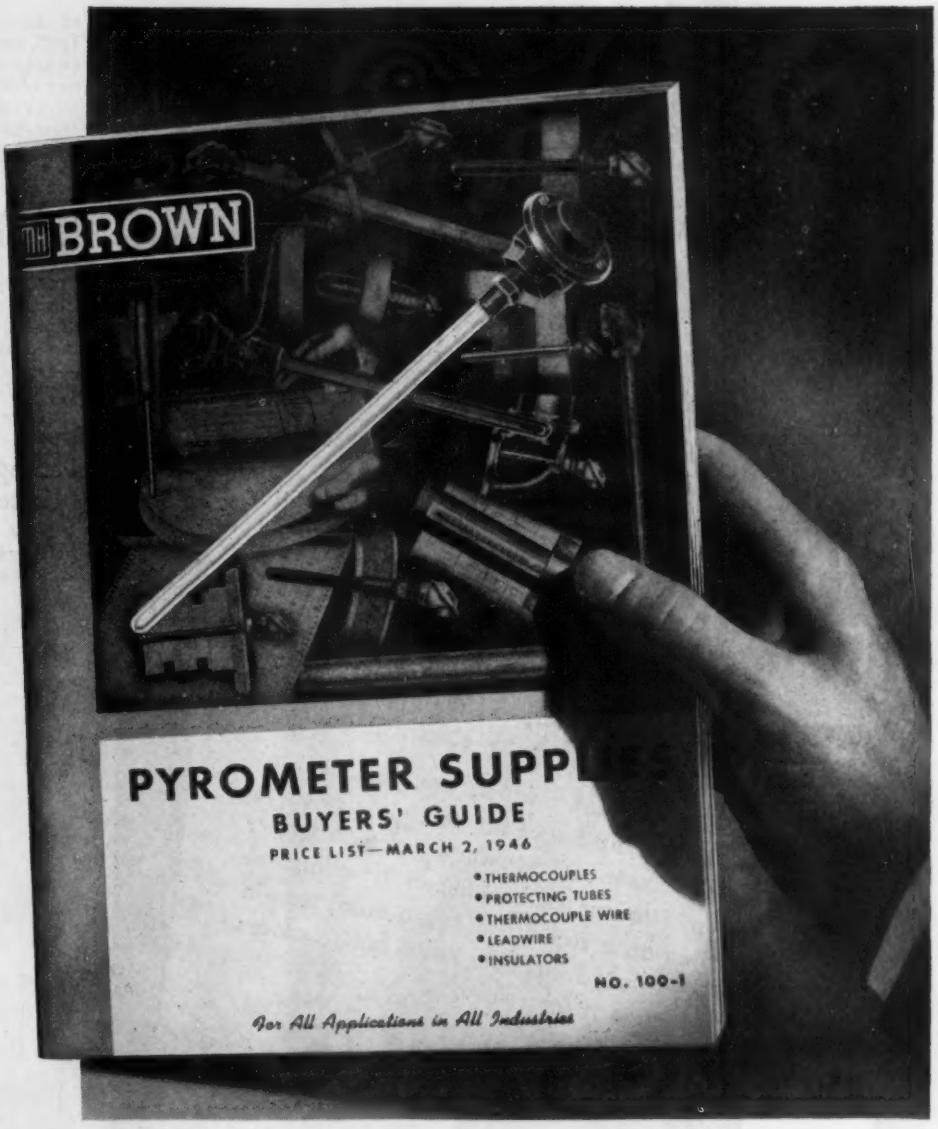

Whether it is for original engineering or replacing worn out thermocouples or leadwire, the Brown Pyrometer Supplies Buyers' Guide is a boon to any department that specifies or orders pyrometer supplies.

This 40-page free book is chock full of informative data, how-to-do-it information, illustrations and specific part numbers with prices. It reduces an often complex subject to A.B.C.

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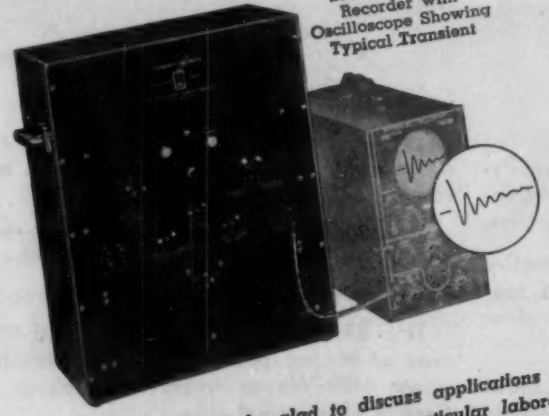

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Brush representatives will be glad to discuss applications of this instrument in solving your particular laboratory or production problems. For complete details write today for technical bulletins.

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of Standards (see *Instruments*, Dec. 1946, pages 732-733). It will detect and closely estimate less than 1 part of CO per 500 million parts of air. Untrained personnel can obtain reliable results. Detector consists of a small glass tube sealed at both ends and a rubber bulb, packed into a pocket kit. When presence of CO is suspected, kit is opened, tip broken off a small tube and one end inserted in bulb to draw air sample through chemicals in tube. If CO is present, yellow chemicals will turn green in thirty seconds, shade of green depending on concentration. A matching color chart indicates concentration. —*United States Safety Service Co., 1215 McGee St., Kansas City, Mo.*

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Pantograph System for Projecting Mid-section and Cavity Contours

New "Pant-O-Jector" System comprises (1) staging fixtures for use on stages of standard optical comparators

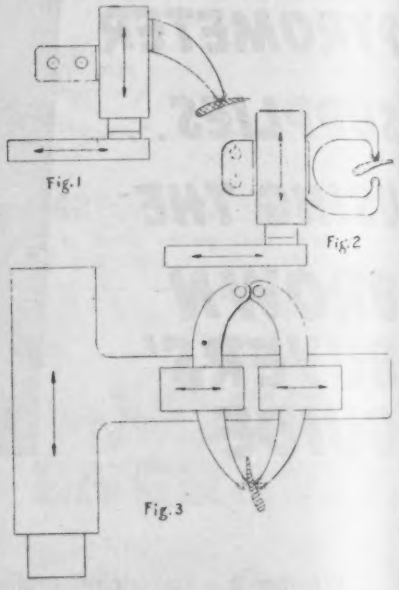


Fig. 1

Fig. 2

Fig. 3

with 14" or larger screens, (2) coördinated chart-gages on glass, (3) special service when desired. Fixtures available in numerous sizes and forms; Figs. 1, 2 and 3 showing three self-explanatory examples (essential parts only) and Fig. 4 showing a "Pant-O-Jector" unit for checking simultaneously both sides of a turbine or compressor blade. System makes possible for the first time 100% inspection of mid-section

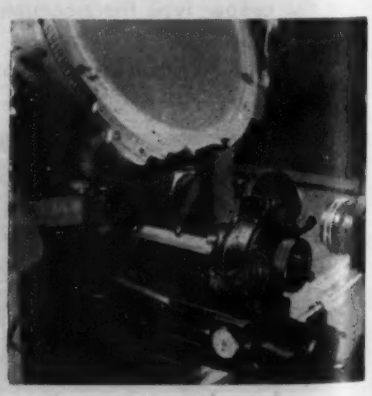
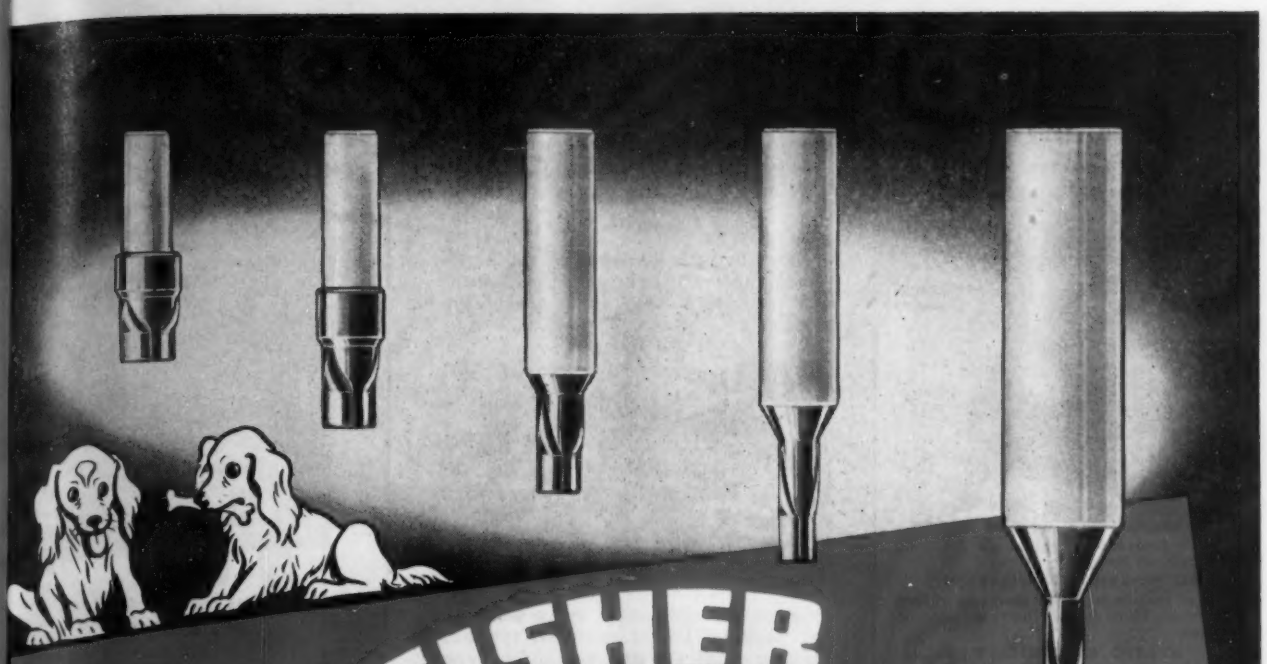


Fig. 4



FISHER
PRECISION CAST STELLITE MICRO-FLUTE
PUP
PROPORTIONAL UNIFORM PERCENTAGE
Inner Valves

Fisher now has available Micro-Flute Pups of No. 6 Stellite. The plug end as shown above is solid cast No. 6 Stellite—precision cast by the lost wax method. The high resistance of No. 6 Stellite to erosion and corrosion—higher than any of the austenitic stainless steels—means Stellite Micro-Flute Pups will maintain their percentage flow characteristics even under most severe applications.

The base and seating surface of the ring is Stellite faced.

Solid Stellite plug end is joined to guide member by welding with stainless welding rod. Guide member is joined to stem member in same manner.

Stellite Micro-Flute Pups are available in orifice sizes of ¼", ⅜", ½", ¾", and 1". Applicable to control valve sizes ½" to 2". Bulletin A-100 gives full details. ***Write for your copy today.***

FISHER
GOVERNOR COMPANY
MARSHALLTOWN . . IOWA

RAWSON ELECTROSTATIC VOLTMETERS

Type 518

Now available to 35,000 VOLTS
Measure true R.M.S. values on A.C., no waveform or frequency errors.

NO POWER CONSUMPTION
Leakage resistance greater than one million megohms. These meters may be used to measure

STATIC ELECTRICITY !
Ideal for measuring high voltage power supplies with zero current drain. Rugged, well-damped movement. All elements surrounded by metal shielding for accuracy and safety.

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RAWSON ELECTRICAL INSTRUMENT COMPANY
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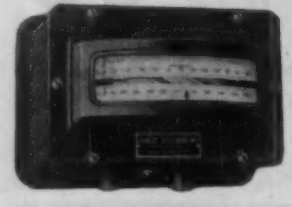
Chicago - New York City - Los Angeles

Wall-Type
INDICATOR PYROMETER

A PRODUCT OF 40 YEARS OF RESEARCH



Model W-1
Switchboard Indicator

Unskilled help may handle this direct-deflection instrument, which needs no manual adjustment. Designed for numerous ranges of temperature, both F. and C.

Write for descriptive Bulletin 400

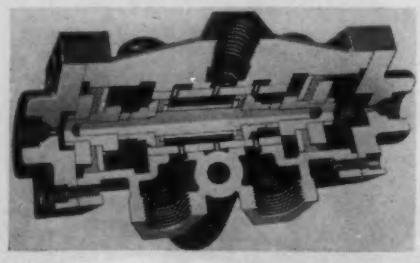
Charles Engelhard, Inc.
233 N.J.R.R. Ave. Newark 5, N. J.

and cavity contours at high speed and low cost (example, 18 dimensions in 15 seconds at 50× magnification, 250 parts per hour).—*Engineers Specialty Division, U.E.& C. Co., 908 Ellicott St., Buffalo 8, N. Y.*

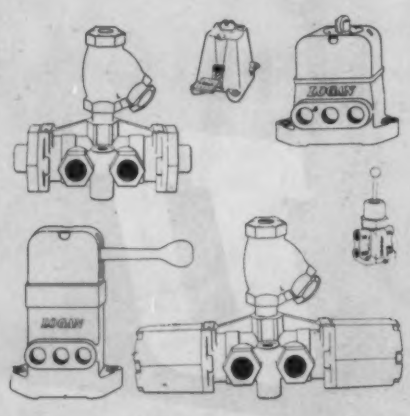
Please mention number 527 when filling out card

Air Control Valves

New air control valves, all completely re-designed, are available in 79 standard models. New sliding piston-type



construction eliminates valve seats and rod packing. Direct operated types include manual (2- and 3-position types, with ball detent or spring return to top, bottom or neutral); toggle; foot; cam; and compact light duty ¼" port 4-way valves operated by push button, toggle, cam or built-in air cylinder. Re-



mote-operated types include Electric (Direct); Bleeder; Pilot Pressure (2- and 3-position types, latter with ports exhausting or blocked in neutral, and returning to neutral by spring or line pressure). Activated by remote 4-way or 3-way pilot operating valves operated by hand, toggle, foot, cam, electric solenoid or built-in air cylinder. Top cover of manual valves can be rotated to place handle in any of four positions at 90° intervals. Parts being interchangeable, valves can be quickly reconverted for other uses. All valves in new line are designed for operation at pressures to 150 lbs./in.^{2}.—*Logansport Machine Co., Inc., 905 Center Ave., Logansport, Indiana.*

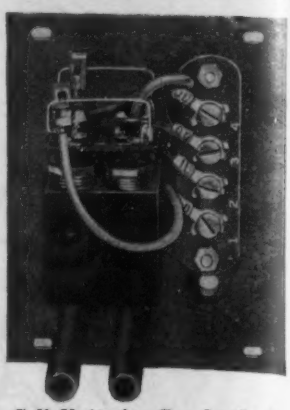
Please mention number 528 when filling out card

Signalling Timer

New "Series S Signalling Timer" closes or opens a circuit at end of interval, operates additional buzzers, bells or lights at remote locations. When pointer is set to desired interval, pilot light goes on and moving pointer rotates anti-clockwise toward zero; when interval is completed, an audible

Engineer your own Gas Synthesis Instruments with

GOW-MAC EVERTITE THERMAL CONDUCTIVITY



Cell Units for Gas Analysis
3" x 4" x 5"

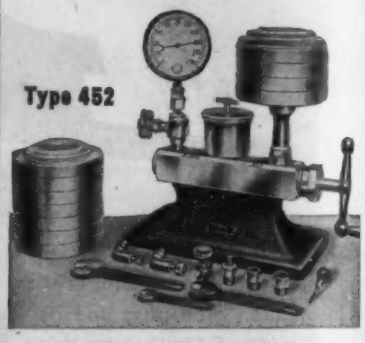
Pressure Tested—No Cements
Diffusion Type—Straight Wire
Panel Mounted or In Housing

Write for Bulletin 41546-MI

GOW-MAC INSTRUMENT COMPANY
22 Lawrence St., Newark 5, N. J.

AMTHOR Dead Weight Pressure Gauge TESTER

Type 452



Modern design and construction puts this rugged precision instrument in a grade above the ordinary dead-weight testers.

Made in ten ranges, to 5000 lbs. maximum.

We guarantee 1/10 of 1 percent accuracy in each range.

The Type 452 is designed for simplicity and compactness. It incorporates the newest refinements and improvements. Adapters and tools are supplied, as well as either carrying case or protecting cover.

Immediate and intelligent attention will be given to your inquiries on all industrial speed measurement problems.

Drop us a line today.

Amthor Testing Instrument Co., Inc.
49a Van Sinderen Ave. Brooklyn, N. Y.

now HAGAN *makes*

Ring Balance meters

Hagan Corporation has acquired all assets of Ring Balance Instrument Company, Chicago.

Manufacture of the full line of Ring Balance instruments will continue at the company's Chicago plant; the design staff has been retained; but these instruments will now be backed by the material and technological resources of the Hagan Corporation.

Sales and service will be handled by the present representatives of the Ring Balance Company, and by the district offices of Hagan Corporation. All activities will be directed from the Hagan offices in Pittsburgh.

Any of these offices will be glad to give you full information concerning Hagan Ring Balance instruments.

Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

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BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

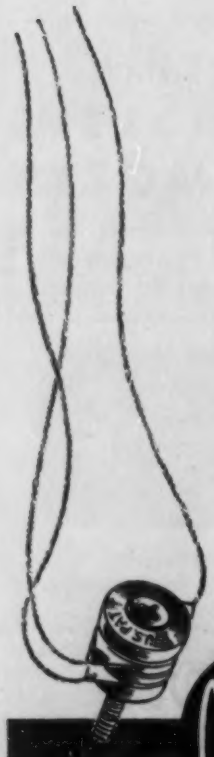
a new **CONANT** service

Balanced Inventory Buying **For Rectifier Distributors...**

Unbalanced rectifier stock conditions are both annoying *and* costly. Now, however, you can avoid having surplus inventories on some items and "out of stock" entries on others with Conant's new Balanced Inventory Buying plan.

As a result of a study of instrument rectifier sales to test equipment manufacturers, Conant is now able to offer you 3 rectifier package assortments for balanced buying. Whatever your volume of business, one of these assortments will enable you to purchase instrument rectifiers with the assurance that your stock on hand will always be properly proportioned.

Prices of the new "packages" run from $28.78 to $120.48. Send a postcard today for full information about quantity and type of rectifiers in each unit. Reply will be prompt and include a FREE copy of the Conant Instrument Rectifier Replacement Guide ... the handiest reference book available on replacements for most test equipment.



CONANT *Instrument Rectifiers*

ELECTRICAL LABORATORIES

6500 O STREET, LINCOLN 5, NEBRASKA, U. S. A.

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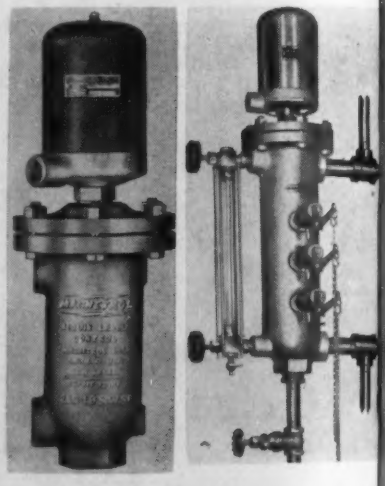
85 E. Gay St., Columbus, Ohio
600 S. Michigan Ave., Chicago 5, Ill.
1215 Harmon Pl., Minneapolis 3, Minn.
518 City Bank Bldg., Kansas City 8, Mo.
1212 Camp St., Dallas 2, Texas
378 Boulevard N. E., Atlanta, Ga.
4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
Export Div., 75 West St., New York 6, N.Y.
50 Yarmouth Rd., Toronto, Canada

alarm sounds and pilot light goes out. Buzzer continues to sound until toggle switch is snapped to "off" or timing interval is again started by moving pointer knob to desired time interval. Rapid resetting of pointer knob, when same time interval is to be repeated indefinitely, is afforded by a quickly adjustable back-stop. Case size 5" × 5" × 3½" deep. Timer operates on 115- or 230-volt 25-, 50- or 60-cycle a.c., voltage and frequency to be specified. Six models are available, maximum intervals 1 min. (1-sec. graduation) to 3 hrs. (5-min. grad.). — *Industrial Timer Corp., 110 Edison Pl., Newark 5, N. J.*

Please mention number 529 when filling out card

Boiler Water-level Controller and Combination Control

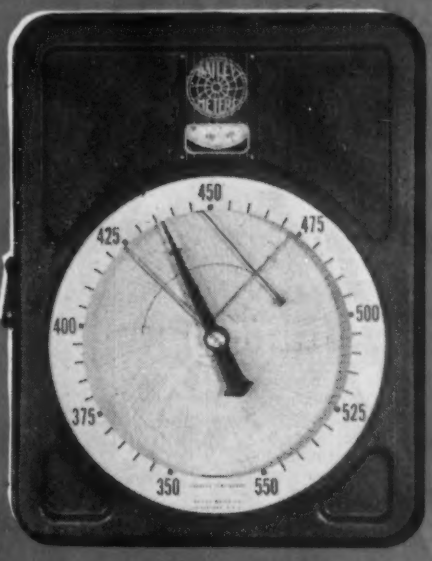
New "Model 126" (125-lb. pressure) and "Model 251" (250-lb.) multi-stage boiler water level controllers provide



through a simple magnetic switching action, pump control, low-water fuel cut-off and low-water alarm. It transmits changes in water level to switching mechanism by magnetic action: no mechanical or electrical connection between pressure chamber and switching mechanism. "Type S Unitary" switching mechanism has mercury switch, magnet, lead wires and terminal strip built into a single unit: simple installation and easy servicing.

New "Model W-126" (125-lb.) and "W-251" (250-lb.) combination boiler water column and controllers combine water column and multi-stage boiler water-level controller in a single unit. Advantages: (1) lower first cost, (2) easier installation, (3) space saving

3 WAYS to CONTROL TEMPERATURE



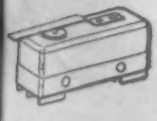
WITH BAILEY PYROTRON ELECTRONIC RESISTANCE THERMOMETERS

1. FOR AIR-OPERATED SYSTEMS

A free floating air pilot valve actuated by the Pyrotron slidewire unit establishes an air loading pressure for the control of valves and drives. Adjustments and relays provide flexibility of range, sensitivity, and speed of response, as well as reset action, easy coordination with other factors, and remote manual control.

2. FOR ON-OFF ELECTRICAL SYSTEMS

By Electronic Relay—Two slidewires, one set manually to the desired temperature standard by a convenient knob and scale, and the other automatically positioned by the Pyrotron slidewire unit, form a control bridge which operates an electronic relay.



By Electric Contacts — Adjustable cam on Pyrotron slidewire unit operates a totally enclosed snap switch.

3. FOR MODULATED ELECTRONIC SYSTEMS

A control bridge formed by two slidewires establishes a small signal voltage which changes in phase and intensity to operate a standard electronic control unit. The d-c output of this unit is accurately regulated according to the signal and applied to a saturable core reactor to vary voltage on the a-c heating circuit.

UNUSUAL FEATURES OF THE BAILEY PYROTRON ELECTRONIC RESISTANCE THERMOMETER

1. Resists vibration and shock.
2. Needs no careful leveling.
3. Motor drive provides abundant power for operation of recording pen, controller, alarms and signals.
4. Simple a-c measuring bridge needs no battery.
5. Sturdy electronic units keep the bridge in continuous balance and replace the usual galvanometer and its attendant mechanism for step by step balancing.
6. Interchangeability of packaged units simplifies replacement.

For details on this unusual Electronic Resistance Thermometer, which indicates, records and controls temperatures between —100°F. and 1200°F. ask for Bulletin 230-A. P-10

BAILEY METER COMPANY

1041 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Processing

TEMPERATURE FLOW
PRESSURE LEVEL
% OXYGEN DENSITY
% COMBUSTIBLES RATIO

STATHAM PRESSURE TRANSMITTER

MODEL P 10

The Statham Pressure Transmitter, Model P 10, is designed to provide electrical indication of high gage pressure.

Increased accuracy is combined with the simplicity of operation, ruggedness, small size and light weight which characterize all Statham Instruments.

Specifications:

Ranges: 50 psi to 5000 psi.
Input power requirements: Dry cells, regulated A. C. or carrier.
Output: Sufficient for direct operation of panel type microammeters, recording oscillograph, recording potentiometer, or cathode ray oscilloscope.
Size: 1⅜ x 4 in. Weight: 14 oz.

Statham Laboratories also makes Pressure Transmitters with full ranges as low as ±0.2 psi, accelerometers, and dynamometers. Our engineering department is at your service to analyze your problems and make specific suggestions for solving them. Write for our catalog.

STATHAM LABORATORIES SCIENTIFIC INSTRUMENTS
6222 BEVERLY BOULEVARD
LOS ANGELES 36, CALIF.

(4) more reliability because it eliminates cross-connection piping, and (5) reduction in boiler maintenance because it requires only one blow-down instead of two.—*Magnetrol, Inc., 2110 S. Marshall Blvd., Chicago 23, Illinois.*

Please mention number 530 when filling out card

Differential-expansion Thermostat

New "Scaico" thermostat utilizes expanding-tube principle: consists of a ½" brass or stainless steel tube, 2"

long, in which heavy-duty contacts are carried on low-expansion nickel-iron struts; outer case is temperature-sensitive element and contact action is caused by difference in expansion rate of outer shell and inner struts. Assembly weighs only 1½ oz., is soldered, welded, or riveted: no linkage or pins used. Result is said to be compact and rugged mechanism responsive to a fraction of a degree change in temperature. Various ranges from −100F°. up to 600°F. Adjustment by turning an adjusting screw. Maximum capacity 600 watts. A larger unit, ⅝" dia. × 3" long, has load capacity up to 2500 watts. New thermostat was originally developed for aircraft use because of its small size and weight and freedom from vibration effects, has numerous other fields of application. Small quantities available from stock, reasonable delivery schedules on large orders.—*Smith Control & Instrument Corp., 1329 Highland Ave., Needham 92, Mass.*

Please mention number 531 when filling out card

Resistance Tester

New "Model B-7 Megohmer" combines an insulation tester and ohmmeter, provides two megohm ranges, two ohm ranges and two test potentials for insulation resistance measurements.

Automatic ELECTRIC PRODUCTS

TIME SWITCHES

Ruggedly constructed *Automatic* Switches have visible dial in tamper proof compact cabinet . . . pure silver contacts . . . 2 to 24 "on" and "off" operations. For any load . . . for every installation an *Automatic* time switch or Interval Timer will deliver superior performance.

Synchronous or Manually Wound

FLASHERS

Automatic heavy duty, motor driven Flashers available in circuit arrangements for every conceivable effect. Pure silver contacts. Models for any load or purpose.

Alternates *Chasers* *Spellers*

RELAYS

Automatic manufactures a complete line of dependable relays for industrial, business machines, radio, electronic and many other uses . . . open, or can type with tube-base, plug-in features.

Consult our Engineering Department

WRITE FOR SPECIFICATIONS AND INFORMATION TODAY

In Switches, Flashers and Relays where dependable performance is paramount, look for the "Diamond Seal for Diamond Quality".

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HARDNESS TESTING...

done WITH NO METAL HAZARDS. The SCLEROSCOPE has done it for the past 39 years.

In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

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Illustrated bulletins free

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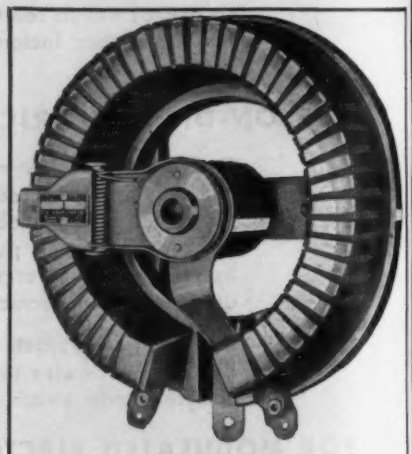
9025 Van Wyck Ave., Jamaica 2, N. Y.



A NEW LINE OF

VITREOUS ENAMELED ROUND RHEOSTATS

7 SIZES: From 50 to 500 WATT

SPRING HINGED CONTACT ARM for uniform, unchangeable contact pressure. Easy and smooth to operate.

Request Catalog No. 4

REX RHEOSTAT CO.
BALDWIN, L. I., N. Y.

Timing tunes for transients

A quarter in the slot . . . and the hotel radio comes to life. The travel-weary guest can relax with exactly two hours of his favorite music. The control that times the program is operated by a Telechron synchronous electric motor.

This is only one of many applications for Telechron motors. Dependable and versatile, they have been used successfully in clocks and timing devices for 25 years—and more. New and unusual applications to automatic timing, switching, recording and control equipment are being developed constantly. Perhaps a Telechron motor is the answer to your needs.

Telechron motors are easily adapted to a wide variety of electric devices—complicated control mechanisms as well as simple switches. They're self-starting, and reach rated speed almost instantly. They operate in perfect synchronism with all commercial frequencies . . . *can't run faster or slower.* Conservative torque ratings, precision building and Telechron's exclusive oiling system assure long, trouble-free service.

A Telechron motor gives your product the extra sales advantage of Telechron leadership. For over 25 years, Telechron has been the largest producer of synchronous electric motors. Every one is Underwriters Laboratories approved. Why not let Telechron's *application engineers* study your motor needs? They'll be glad to make recommendations. Just address Motor Advisory Service, Dept. B, Telechron Inc., Ashland, Mass.

Telechron Motors Are Now Being Used for:

- Stoker, Oil Burner and Temperature Controls
- Industrial Process and Cycling Timers
- Business Machinery
- Medical Devices
- Household Appliance Timers
- Musical Devices

Telechron
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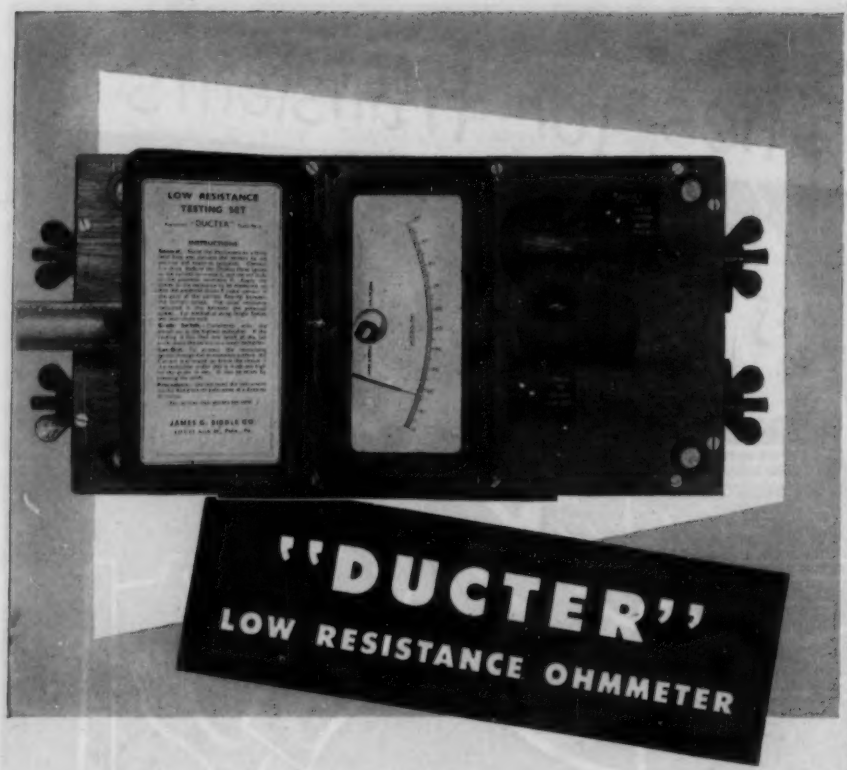
SYNCHRONOUS MOTORS

The First and Favorite Synchronous Electric Timing Motor



HERE'S a rugged, portable, direct-reading, and yet accurate *field* instrument for measuring resistance down to .000001 ohm (1 microhm) that can be taken right to the job and operated by *one man* simply applying a pair of hand spikes and reading the position of a pointer over a scale.

The "Ducter" Ohmmeter is invaluable for detecting trouble in switches and circuit breakers . . . for measuring any type of low electrical resistance or contact such as armature and transformer windings, soldered joints, etc.

In one operation, the "Ducter" Ohmmeter performs what otherwise requires more complicated equipment as well as both training and practice in low resistance measurement. You'll find the story of this member of the famous "Megger"* family of resistance measuring instruments in your free copy of Bulletin 24-25-I.

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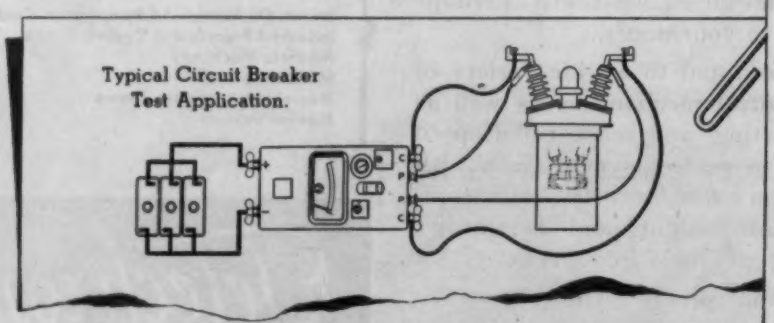
Typical Circuit Breaker Test Application.

James G. BIDDLE CO.

ELECTRICAL & SCIENTIFIC INSTRUMENTS

1316 ARCH STREET • PHILADELPHIA 7, PENNA.

Feature is unusual readability: on 0-200-ohm scale, for instance, testing to as low as 0.1 ohm is possible. Aggregate megohm scale (dividing point 1 megohm) is close to 5". There are said to be more scale divisions on megohm scale than on any comparable instrument. "Model B-7" employs a vibrator transformer circuit to step up two No. 6 dry cell batteries connected in series to furnish test potentials of 500 and 250 volts d-c. Another feature is ease of changing batteries.—*Herman H. Sticht Co., Inc., 27 Park Place, New York 7, N. Y.*

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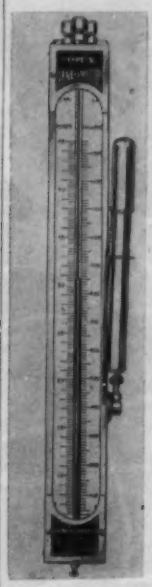


Liquid Level Gages

New "Type S Tank-O-Meter" for measuring contents of tanks at any remote point regardless whether tanks are open, vented, under pressure, or under vacuum, can be furnished with high or low alarm switches for closing or opening any circuit at any predetermined high or low levels. Fifty-two standard models for measuring liquid depths ranging from one foot to seventy-five feet. Can be furnished for hand pump or compressed air operation. — *Uehling Instrument Co., 473 Getty Ave., Paterson 3, N. J.*

Please mention number 533 when filling out card

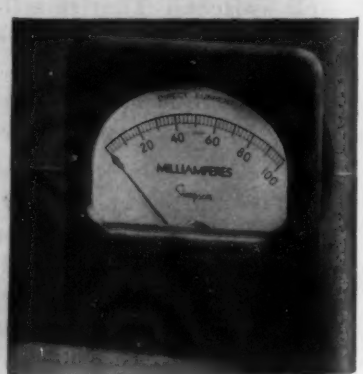
Full-wave CuO Rectifier

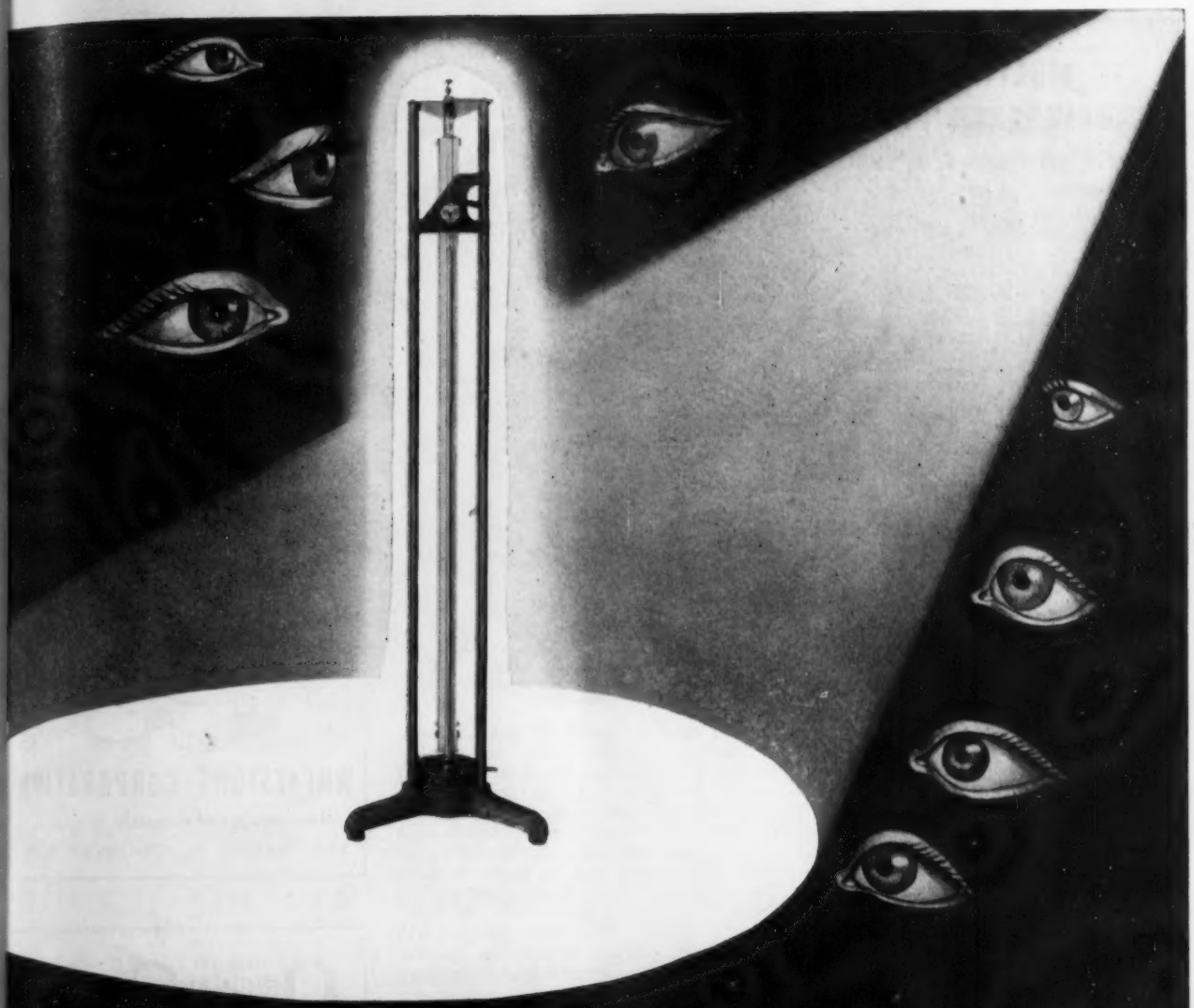
New permanent full-wave copper-oxide rectifier for portable-radio low-voltage battery charging is rated at 1.5 amperes continuous current, is light in weight, rugged, dependable, small in size (a single 2" sq. plate) and with versatile mounting provisions.—*Bradley Laboratories, Inc., 82 Meadow St., New Haven 10, Conn.*

Please mention number 534 when filling out card

Illuminated-dial Electrical Instruments

New method of illumination of instrument faces does away with translucent dials, is said to "flood every fraction of the dial face with an even radiance, doing away completely with shadow spots." A Lucite cone carries light from a recessed bulb in back of instrument through front edge of cone





Anyway you look at it . . . .

—the W & T Mercurial Barometer is a headline performer. Here's why—

1 It can be used with equal ease as an accurate, dependable manometer by simply opening a valve.

2 Temperature compensation is accomplished by a twist of a dial.

3 Well level corrections for each reading are eliminated.

4 A magnifying eyepiece minimizes reading errors.

5 The knife-edge float on the mercury column permits readings to 0.005 of an inch of mercury with scales graduated in inches and to 0.1 mm of mercury with scales graduated in millimeters.

6 It can be used for any pressure or vacuum measurement from zero absolute to 31 inches of mercury.

7 The column is made from precision bore tubing to permit interchangeability.

8 It's built throughout to exacting standards for dependability, accuracy and long life and is supplied for either bench or panel mounting.

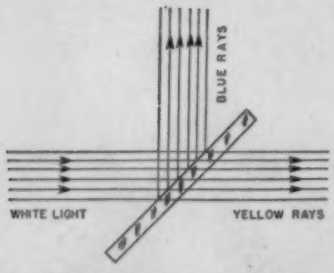
Write today for detailed information on this versatile precision instrument. A-55

WALLACE & TIERNAN

BELLEVILLE 9 **PRODUCTS, INC.** NEW JERSEY

FS MULTI-LAYER INTERFERENCE FILMS

Dichroic & Achromatic Beam Splitters



Chromatic Spectral Selection Effect: a certain portion of the spectrum is reflected, the remainder transmitted.

Achromatic Spectral Selection Effect: the incident light is split into two beams, one reflected, one transmitted, each beam retaining the spectral properties of the original incident beam.

Transmission or reflection peaks as high as 85 to 90% but the spectral bands are relatively broad.

Submit your problems and ask for bulletin MI-318 giving graphs of standard types now available.

FISH-SCHURMAN CORPORATION
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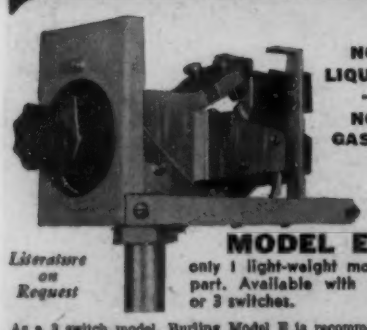
Fish-Schurman

BURLING TEMPERATURE LIMIT SWITCHES



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Literature on Request

MODEL E
only 1 light-weight moving part. Available with 1, 2 or 3 switches.

As a 3 switch model, Burling Model E is recommended for use (a) where load is divided into 3 parts, (b) where 1 switch is used for controlling, one as a high limit, one as a low limit, (c) to give definite stops or position to a 3 or 4 position diaphragm motor, (d) to give 3 speed control of variable speed motor.

Accurate, rugged, dependable. Corrosion and heat resisting tube. Dial pointer for easy setting. Locking screw locks temperature setting. Increased adjustable range to 700-1600°. Dimensions: 7¼" x 3⅝" x 3⅛". Vapor tight base and cover with gasket available at slight extra charge.

INSTRUMENTS ALSO BUILT TO SPECIFICATIONS

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BURLING INSTRUMENT CO.
251C Springfield Ave.
Newark, N. J.

which entirely surrounds dial face. This permits using standard metal dial. Pointers cannot stick or readings be distorted. New illuminated instruments are available in 2" and 3" sizes, in both rectangular and round cases.—*Simpson Electric Co., 5216 Kinzie St., Chicago 44, Ill.*

Please mention number 535 when filling out card

All-purpose Draft Gage

New "Model MZF" all-purpose draft gage is supplied with 9 feet of rubber tubing and a 5" metal sampling tube,

can be used at point of measurement, or at a distance; can be quickly mounted on a panel, hung on a wall or simply set on any flat surface. An exceptionally large area diaphragm is enclosed in a metal housing. Distinctive 3"-wide scale can be read in dim light; zero adjustment can be made without removing any parts. Dimensions 4¾" × 7½" × 3" deep. Illustrated is 0.25" gage in production; other ranges will follow.—*Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Penna.*

Please mention number 536 when filling out card

Periscopic Aircraft Sextant

New periscopic sextant is designed to increase safety for crews and passengers by permitting structural changes that will eliminate the plastic astrodome. It will remove danger to passengers caused by explosive decompression; increase speed of airplane by eliminating drag of astrodome; simplify taking astronomical sights for accurate navigation. A portion of periscope, a little more than 1" diam. × 1½" long is exposed through a special mount in skin of plane. Mount is sealed with a universal joint assembly. Sextant is removed from mount and stored within plane when not in use. Installation is

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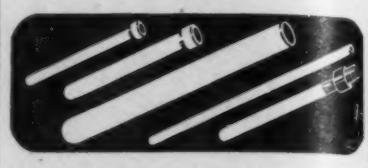
for Thermocouple Protection or for Radiant Target Sighting



Montgomery high refractory tubes, porcelain, mullite and corundum, are widely used in applications above 2000°F. They are available in all popular and special sizes.

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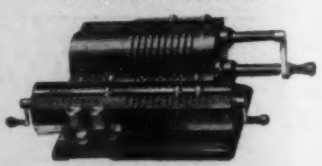

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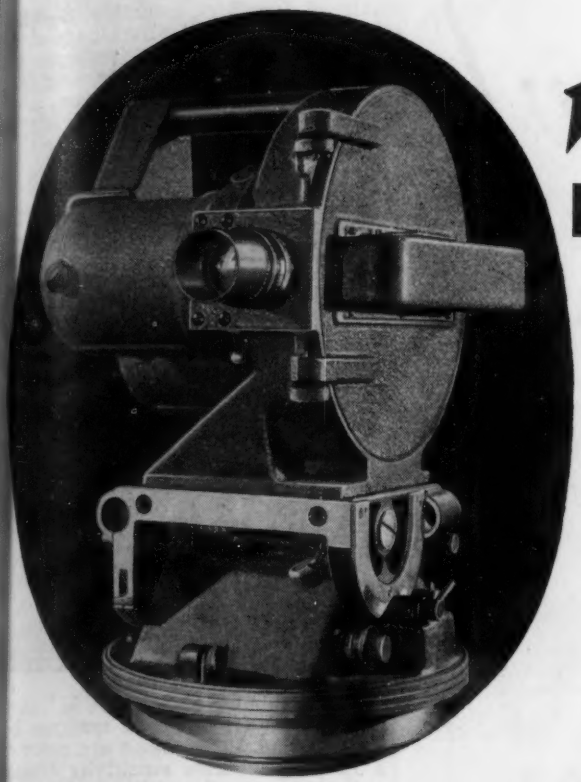

Western Electric
FASTAX CAMERA

World's fastest portable motion picture camera aids in research, design engineering, and testing

The Western Electric Fastax Camera photographs in motion pictures all kinds of short-duration phenomena, reveals the secrets of rapidly moving parts, solves many industrial problems.

You now have a choice of three models, all designed by Bell Telephone Laboratories: 8mm—taking from 300 to 8,000 pictures per second; 16mm—150 to 4,000 pictures per second; 35mm half-frame—500 to 3,500 pictures per second. They have an improved and fully coated optical system . . . make pictures indoors or outdoors . . . in black-and-white or color.

When Fastax pictures are projected at the normal speed of 16 frames per second, a time "magnification" of from 10 to 500 times allows you to see exactly what has happened.

In research and design engineering of products having moving parts — as well as in testing materials and finished products—the Fastax Camera is an invaluable tool that shows up frailties and leads to better design.

For complete information, send the coupon—or call your local representative of the Graybar Electric Co.

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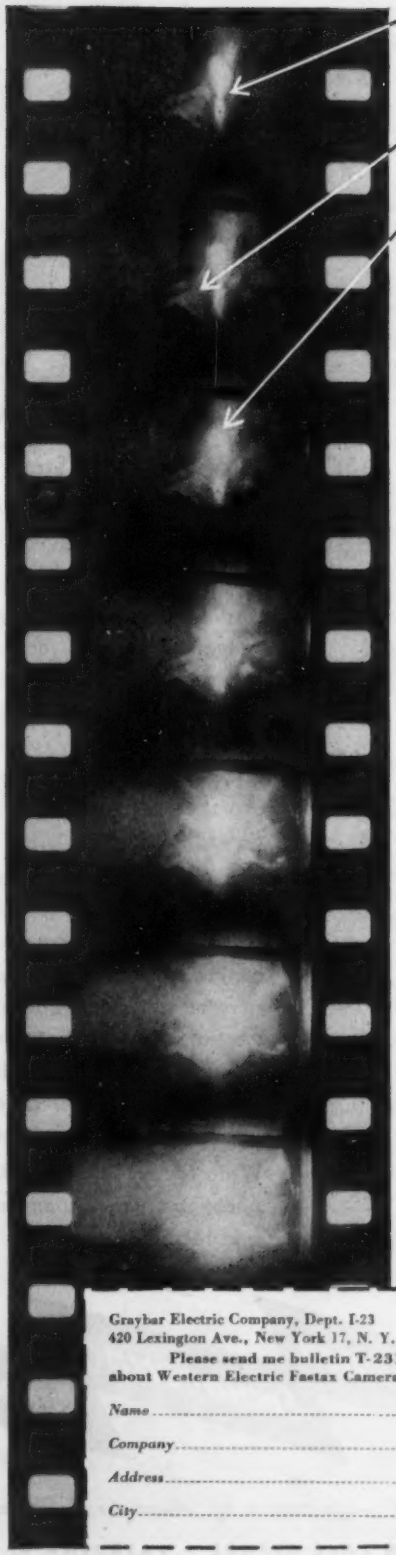

SEE how it works for the electric power industry

These unretouched Fastax pictures are taken from a study made by the I-T-E Circuit Breaker Company, Philadelphia, to show contact operation and the arc occurring when an I-T-E circuit breaker "makes" and "breaks" contact. Here you see the beginning of the "break" in a circuit carrying 12,000 amperes at 350 volts. The time covered by these seven frames is only *1.7 thousandths* of a second.

Pictures were made on 16mm film at a speed of 4,000 frames per second.

The Fastax Camera is ideal for studying many types of phenomena as well as the functioning of motors, generators, governors, fans, communications equipment and other electrical products.

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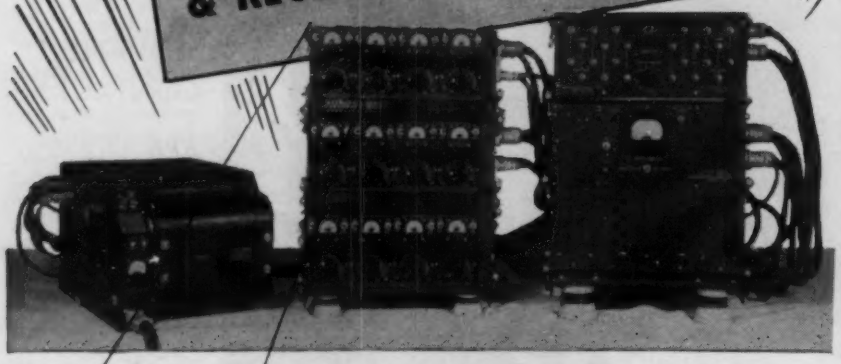
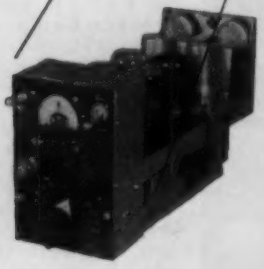


Consolidated Unitized Static-Dynamic

10-kc. Carrier System "C"



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Bridge Amplifiers
—Type 1-114. Unitized self-contained assembly —Weight—3.5 pounds.

10-kc. Oscillator
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This new development in measuring and recording equipment offers a light, compact system having high-frequency response, maximum sensitivity and stability. The accuracy of recorded static or dynamic information through a frequency range of 0 to 1,000 cps. is well within limits required by research laboratories and engineering development organizations.

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Write today for information concerning application of this equipment to your measuring and recording problems.

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designed for shock mounting. Seal between assembly and aircraft structure withstands differential pressure of 15 lbs./in.².—*Kollsman Instrument Div. of Square D Co., 8008 45th Ave., Elmhurst, L. I., N. Y.*

Please mention number 537 when filling out card

Pocket-size Ohmmeter

New inexpensive prod-type pocket-sized ohmmeter for spot-checking circuit components, relays, etc., is en-

closed in tubular plastic case ⅞" diam and 5¾" overall. Direct readings between 0 and 10,000 ohms are given on a 1.5-ma. full-scale sensitivity Weston indicator in series with a 1000-ohm molded carbon resistor and a standard penlight dry cell. Test electrodes include a built-in stainless steel prod and one secured to tip of a 17" test cord.—*Radio Tube Div., Sylvania Electric Products Inc., 500 Fifth Avenue, New York 18, N. Y.*

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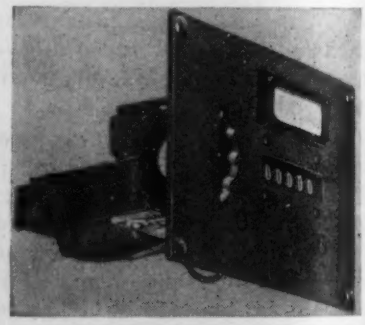
Electric Counters for Panel Mounting

New "Wizard Panelmount" electrically-operated counters are designed for installation, reading and reset from



front of panel. Any number can be grouped on a centralized count control panel; or on a panel with other flush-mounted instruments, or on individual machines. They are made in 4- and 6-digit models with front-of-panel knob reset or key reset, in any required voltage up to 220 a.c. or d.c.—*Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.*

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Fiber Extensometer

New "Sookne-Harris Fiber Extensometer" for studying load-elongation

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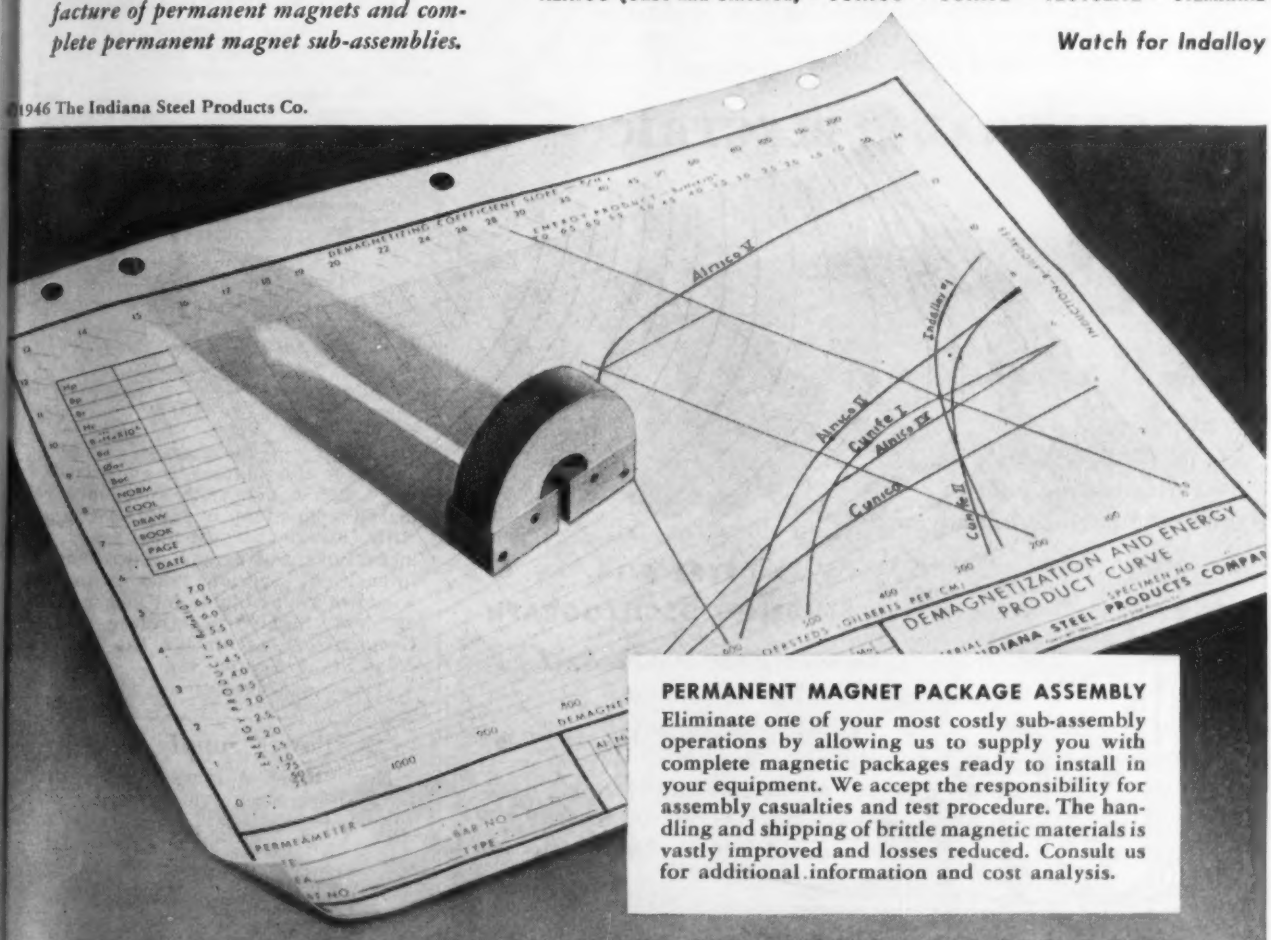

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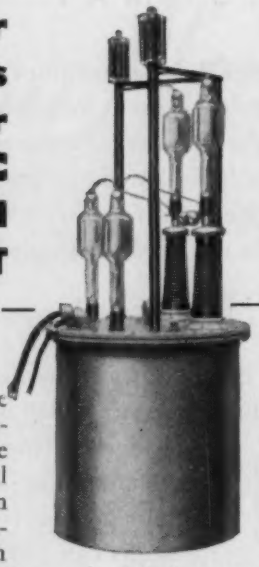

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GENERAL ELECTRIC

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properties of single fibers utilizes principle of an automatic Chainomatic balance, produces an ink-drawn record of load-elongation characteristics of almost any textile fiber. Recording is accomplished by a capillary-flow pen on ordinary graph paper. Several ranges of loads and rates of extension are provided. In addition to the load-elongation curve to the break, one or more hysteresis cycles can be readily obtained to permit study of a fiber's ability to recover from extension. Instrument records in a form suitable for evaluation of fundamental parameters obtainable from load-elongation curves, such as Young's Modulus, work required to elongate to a given extension temporary set, etc. Relaxation curves, in which rate of decay of tension at a constant elongation is studied, are likewise within scope of instrument. With slight modification, apparatus is also capable of providing sensitive measurements of folding properties, especially flexibility and resilience, of lightweight fabrics, or compressional properties of pile fabrics at extremely low pressures.—*Harris Instruments, Inc., 1246 Taylor Street, N.W., Washington 11, D. C.*

Please mention number 540 when filling out card

Geiger-Muller Counter Tubes

New all-metal Geiger-Muller Counter Tube is said to offer many advantages by new construction, among them: (1) Mechanical robustness; (2) Active diameter of counter nearly equal to outside diameter and active volume

maximal for tube size; (3) Low intrinsic background count. A wide variety of sizes is offered ranging from ½" diameter and ½" long to 3" diameter and 5 feet long. Operating voltage is about 1000 volts; cosmic ray efficiency is better than 99%; plateau (range of operating voltage) is 100 volts or more and change in counting rate over this plateau is guaranteed to be $< 0.05\%$ per volt. Tubes are furnished separately or supplied complete with auxiliary systems, ready for measurement of gamma and cosmic ray intensities. Special tubes with thin windows are available for measurement of less highly penetrating rays.—*Geophysical Instrument Co., 1820 N. Nash St., Arlington, Va.*

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Power Supply Unit

New "Model A Power Supply Unit" is claimed to provide "much better voltage regulation than has heretofore

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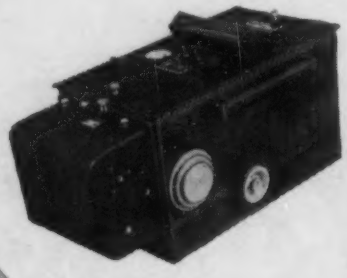
must train for TOMORROW — a challenge intensified by the accelerating pace of scientific and engineering advance.



Specially designed to meet the needs of modern education, is the NEW . . .

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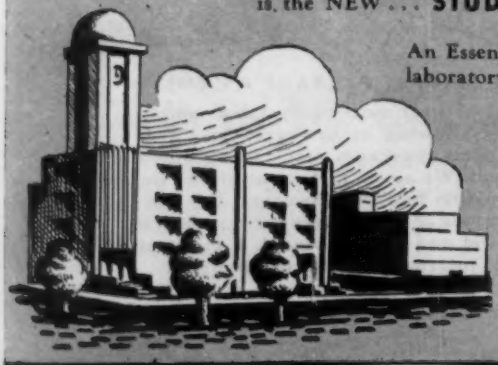

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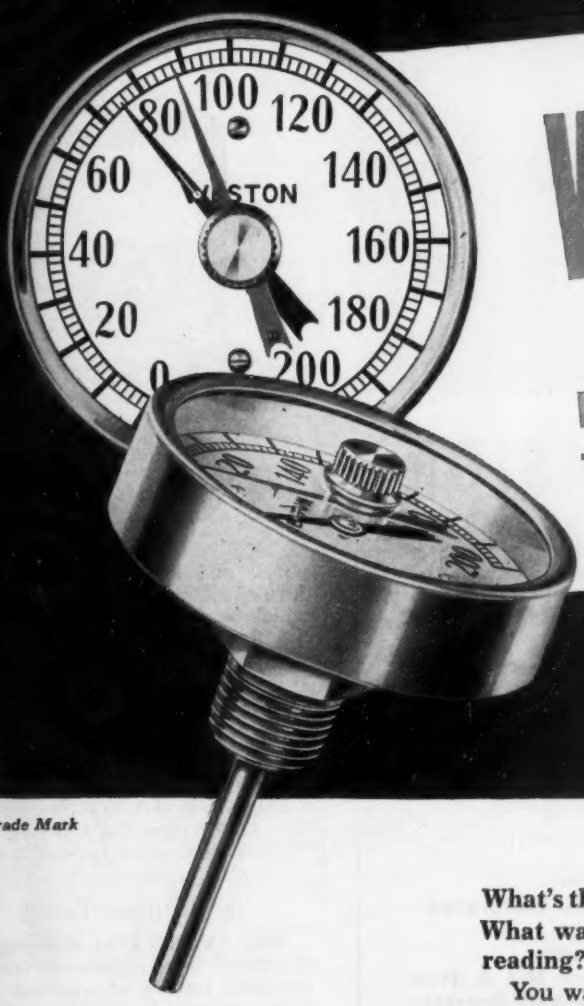

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MAX-MIN* THERMOMETER

*Registered Trade Mark

What's the present temperature of that transformer oil? What was the highest temperature reached since last reading?

You want the answers to both these questions—and the MAX-MIN gives them... accurately!

The red index pointer on the MAX-MIN is manually set to either the low or high side of the main indicating pointer. When set on the high side, for example, it moves as the temperature increases, always remaining at the extreme temperature reached, until manually re-set. Thus in one quick reading you get both *present* temperature and the *peak* temperature since last reading.

For complete details see your jobber or local Weston representative. Weston Electrical Instrument Corporation, 591 Frelinghuysen Avenue, Newark 5, New Jersey.

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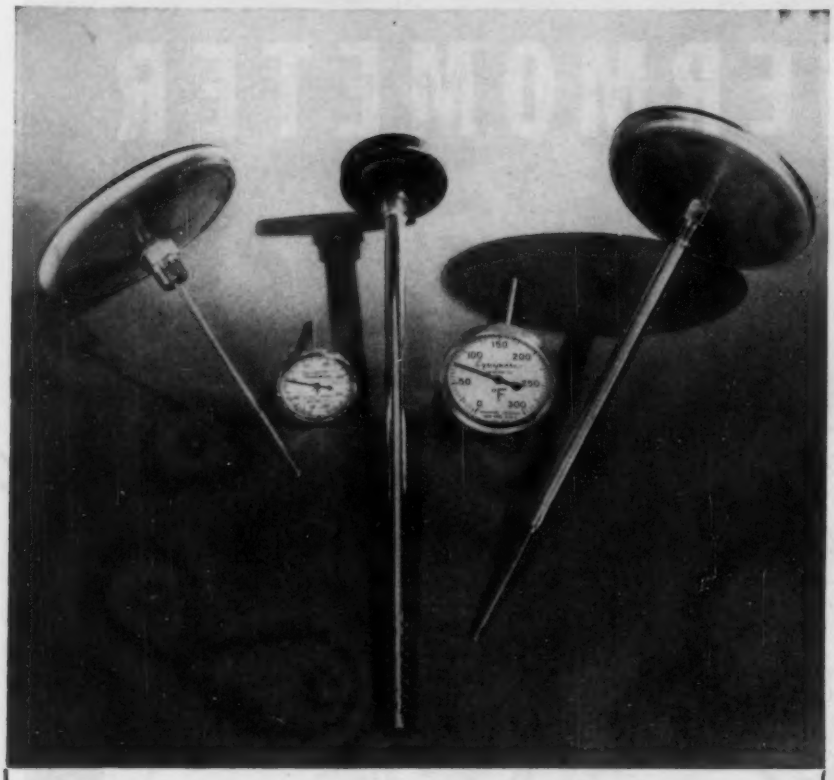

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been possible in conventional type power supply units." It can be used for any purpose where a 6- or 12-volt source of power is required. Unit is described as consisting of two 6-volt 7.5- ampere filtered d-c. power sources which can be placed in parallel for 15-ampere continuous service or in series for 12-volt 7.5-ampere continuous service. Weight 31 lbs.; dimensions 7¾" × 7¾" × 11¾" long.—*Electro Products Laboratories, Inc., 549 W. Randolph St., Chicago 6, Illinois.*

Please mention number 542 when filling out card

Electrical Appliance Tester

New "Model 390" electrical appliance tester, described as "no larger than a man's hand, no heavier than an average

novel, and rugged as a bull-pup," is furnished with a "Break-In" plug which has four color-coded leads. Leads are first attached to instrument, then plug placed in an outlet and appliance is plugged into it. Voltage readings will register immediately. Then, to get wattage or ampere readings, depress one of two buttons at bottom of panel. Ranges: a-c., volts: 0-150, 0-300; amperes: 0-3, 0-15; watts: 0-300, 0-600, 0-1500, 0-3000.—*Simpson Electric Co., 5216 Kinzie St., Chicago 44, Ill.*

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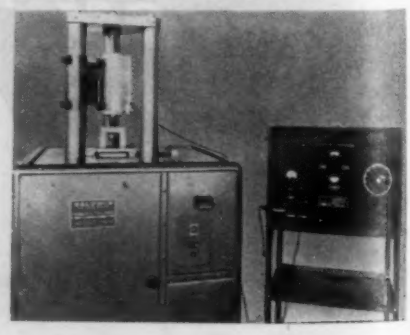
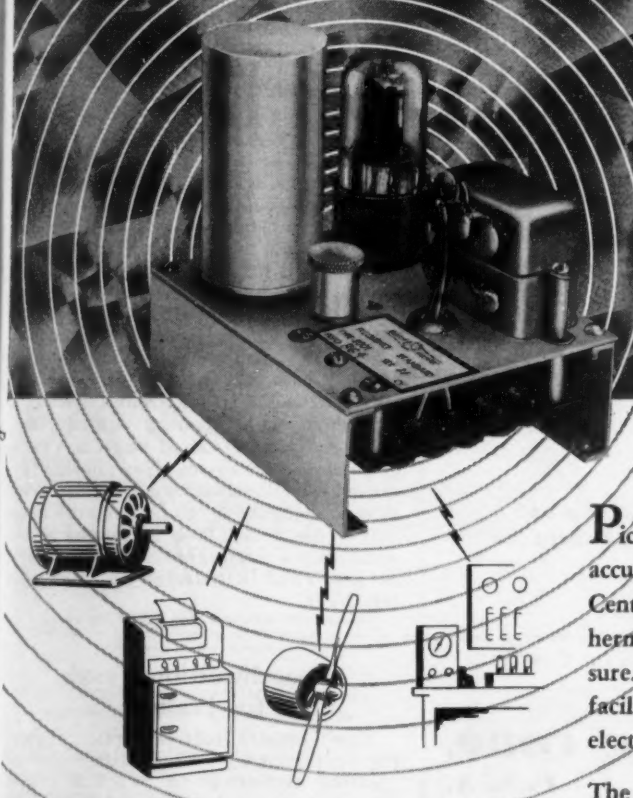
Fatigue Tester

New "Model SF-4 Sonntag Fatigue Machine" is equipped for tension-compression testing at ambient and high temperatures. It embodies principles of Sonntag Universal Fatigue Machines, particularly automatic maintenance of constant load. Maximum capacity in either direction is 10,000 lbs. Static preload capacity, 0 to 5,000 lbs.; alternating (dynamic) load capacity, ± 5,000



PICK A NUMBER



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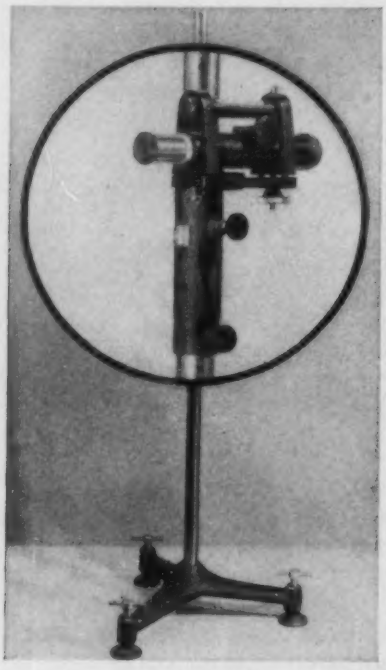
Gaertner

M909-M910 CATHETOMETERS



For vertical measurements requiring an inexpensive yet reasonably accurate instrument. Lightweight and portable.

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M910: 100 cm.

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Precision scale divided into millimeters with each centimeter numbered. Vernier reads to 0.1 mm.

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Of nickel-plated selected steel. 30 mm in diameter.

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Cast iron. Tripod design. Furnished with leveling screws and foot plates.

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Magnification: at infinity 8.5X, at 60 cm 17.5X.

Rack and pinion focusing.

Objective aperture 25 mm, 90° cross hairs.

Mounted level provided.

CARRIAGE
Tubular bronze casting, provided with a positioning clamp and a clamp collar which allows free rotation of the telescope about the vertical guide without change of height.

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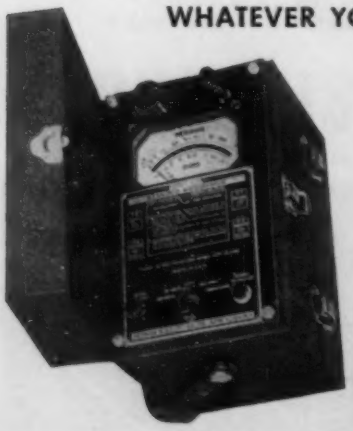
0-20, 0-200 MEGOHMS. 0-200, 0-20,000 OHMS.



Reads as low as 1/10 of 1 Ohm to as high as 200 Megohms. 2 Test Potentials 250/500 Volts. No cranking, no wavering of pointer. Saves time and effort. Simplifies Insulation Testing. Ideal for low resistance testing too.

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lbs.; speed of testing, 3600 load cycles per minute; maximum movement of reciprocating platen, ± 1/16". Weight 3,000 lbs., over-all dimensions 43" × 43" × 75" high. Dynamic load is applied by means of a rotating eccentric mass. Eccentric has micrometer screw adjustment, graduations reading in units of pounds.—*Testing Equipment Div., The Baldwin Locomotive Works, Philadelphia 42, Penna.*

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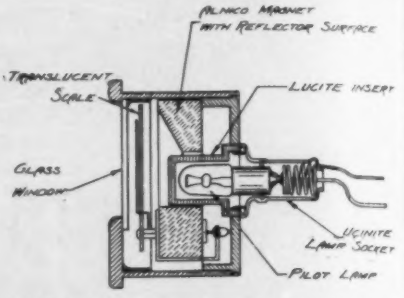
Illuminated-dial Electrical Instruments

New dial-illuminated panel-type instruments are free from two drawbacks of former design: (1) aperture in back



where bulbs were inserted and where thermal currents sucked in dust and other foreign matter, (2) frequent use of oversized replacement bulbs which were forced into opening and damaged mechanism. New design, applicable to all 2½" and 3½" Marion round and square instruments, 4½" rectangular instrument and "Model 52S Tuning Meter" (but not to Marion "Hermetics"), utilizes a transparent Lucite cavity which seals opening against dust, while controlling size of bulbs and safeguarding mechanism. New design assures even illumination across dial with a new specially-developed Alnico magnet whose front face is shaped somewhat like a flashlight reflector.—*Marion Electrical Instrument Co., Manchester, N. H.*

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Heat-distortion Tester for Plastics

New "Aminco Heat Distortion Tester" for determining heat distortion of plastics according to A.S.T.M. D648 comprises an oil bath heated by a 2000-watt immersion heater, a centrifugal pump for circulating bath liquid, a coil for cooling bath liquid to room temperature after each test, a synchronous-motor-driven bimetallic thermoregulator, a control box, four specimen holders, and a loading stand for specimen holders. Thermoregulator automatically maintains a 2°C. per minute rate of temperature rise throughout range from ambient to 150°C. Weights permit total loads of 625, 1,250 and 2,500 grams to be imposed on loading rod of each specimen holder. — *American Instrument Co., Silver Spring, Md.*

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Piston-cam Contour Gage

New "Electrolimit Contour Gage" is a two-station gaging fixture designed

Arnold presents:

another step towards a complete line of permanent magnet materials . . . . .

CAST ALNICO I

CAST ALNICO II

CAST ALNICO III

CAST ALNICO IV

CAST ALNICO V

CAST ALNICO VI

CAST ALNICO XII

SINTERED ALNICO

SINTERED ALNICO

In general SINTERED ALNICO MAGNETS do not compete with, but rather supplement, magnets produced by the cast method to widen the scope of potential permanent magnet applications.

Alnico magnets weighing roughly one ounce or less should be produced by the sintered method.

Heavier magnets of more intricate shapes can be produced. For some applications Sintered magnets are more economical because:

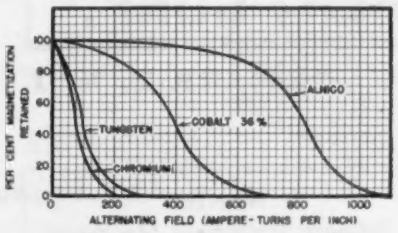
1. Magnetic characteristics are practically the same as Cast Alnico.
2. Sintered Alnico is a fine-grain, homogeneous material which has more uniform flux density, is easier to grind, and provides better surface finish.
3. Sintered Alnico magnets can be produced to closer dimensional tolerances:

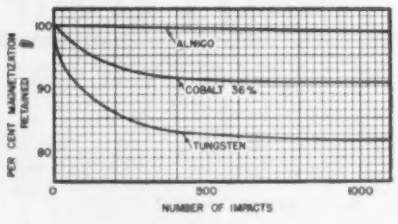
SINTERED ALNICO II	CAST ALNICO II
0.000 to 0.125 — + .005	0.000 to 2.00 — ± 1/64
0.126 to 0.625 — + .010	2.0 to 4.0 — ± 1/32
0.626 to 1.250 — + .015	4.0 to 6.0 — ± 3/64
1.251 to 3.000 — + .062	

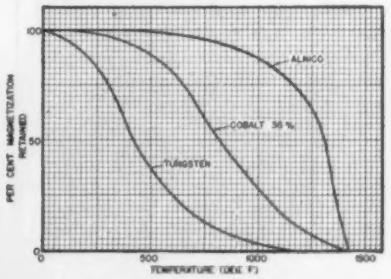
   Grinding can in many applications be eliminated.
4. More intricate shapes, including holes, inserts, etc., are more feasible.
5. Transverse modulus of rupture is several times greater.

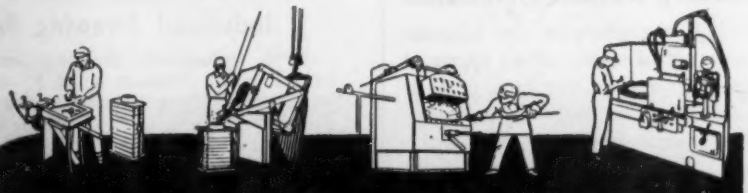
All Alnico, and particularly Sintered magnets, have very high values of Coercive Force (which is the capability of resisting demagnetization or loss of magnetism due to stray fields and from heat and vibration).

The curves show roughly the effect of these demagnetization factors on Alnico compared to other alloy steels.









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for checking cam contour of centerless cam ground pistons. It consists of a floating pressure shoe arbor mounted on a slide so that arbor may be pulled out to install piston for gaging and to remove piston after it is measured. Arbor assembly rotates through 180°. Two "Electrolimit" heads indicate cam contour. Each head has a floating gaging point and a fixed pickup point.—*Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford, Conn.*

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Pocket Microscope

New "Ederscope" is a 25× pocket microscope (size and weight of a fountain pen) for professional as well

as student use. It bridges gap between low-power magnifiers and expensive bench microscopes. Optical system is said to comprise finest precision ground and polished lenses. Definition is sharp and there is no distortion over full field. No support is required. Barrel and focusing extension are made of stainless steel.—*Schneider-Cogswell, Inc., 1849-I North Halsted St., Chicago 14, Illinois.*

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New industrial drawing set comprises beam compass with 8" and 13" beams, 6" giant bow compass, ruling pen with club style wood handle and draftsman's refillable pencil that can be converted into a double-point pencil. New feature of ruling pen is calibrated adjusting collet that enables user to regulate opening of nibs and at the same time record desired setting for future use: desired width of line can easily be duplicated. New giant bow compass feature: lead of pencil part can easily be advanced, by slightly turning adjusting collar, to desired

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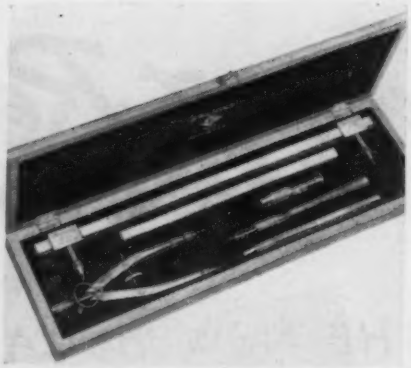

length for easy sharpening without soiling fingers or smudging tracings. Compass draws circles from 1/16" to 8" in diameter. — *Charles Bruning Co., 4754-18 Montrose Avenue, Chicago 41, Illinois.*

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The New "Model CSD-15 Trutorq Screw Driver" operates on friction-disk principle, with accuracy said to be within a fraction of an inch-pound after as many as 300,000 continuous operations. Calibrated head allows operator to set it at any desired torque (from 1 to 15 inch-pounds), without the use of other calibrating devices. Maximum diameter of handle is ⅞"; weight 3½ oz.; length complete with blade is 6¼". No springs, no pointers, and no dials to read. Special design of handle is said to provide maximum comfort and facility in operation. Various blades and bits available. — *Airdraulics Engineering, Inc., New Canaan, Conn.*

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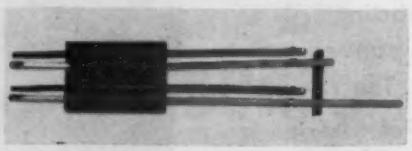
Standard Contact-spring Assemblies

New specification sheet on contact-spring assemblies contains detailed dimensional drawings of three groups



of standard contact springs, permitting a selection for conventional spring stack-up in a wide range of circuit possibilities, and enabling engineers to specify standard tooled parts.—*P. R. Mallory & Co., Inc., Indianapolis 6, Ind.*

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Fog-preventive Glass Cleaner

New "C-All" is a glass cleaning anti-fogging agent for use on instrument covers, eye glasses, and any other glass surfaces subject to fog formation. It is a water white liquid applied with a cloth and wiping until clean. "C-All" cleans glass surface and deposits an invisible film that "prevents fog formation for a relatively long time."—*Engineering Associates, Inc., St. Charles, Illinois.*

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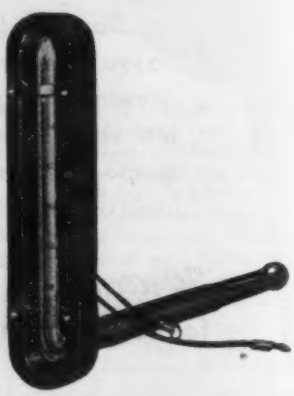

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GUEST EDITORIAL

Measurement—Tool of Science and Industry*

By **HUGH L. DRYDEN, Associate Director, National Bureau of Standards**

IT is a pleasure to bring to the Instrument Society of America the greetings of Dr. Condon and the staff of the National Bureau of Standards. The primary function of the Bureau is to provide fundamental standards of measurement and to investigate problems connected with their application in science and industry. Other functions are the conduct of numerous measurements in connection with the day-to-day business of the Federal government and the conduct of scientific research in the fields of physics, chemistry, and engineering. Your function is to devise, produce and use instruments by means of which standards are widely disseminated and innumerable physical magnitudes and properties of materials are measured. We thus have a community of interest in the broad subject of measurement.

The rapid growth of your own society is evidence of the universal and indispensable rôle of measurement in our modern world. To act intelligently requires knowledge and knowledge is often attainable by measurement. As Lord Kelvin so clearly stated many years ago:

> When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind.

Your field and ours is to find methods of expressing desirable and undesirable attributes and states in numbers, to promote agreement on these methods, and to provide the instruments for accurate measurement.

I propose tonight to consider with you our common responsibility, the purposes to be served in science and industry by measurement, and some of the more recent trends in the development of instrumentation. Some of these trends I will illustrate from recent work at the Bureau.

Our Common Responsibility

I am constantly amazed by the general public's confidence in the readings of any instrument having a good appearance. The automobile driver swears by his speedometer; doesn't the needle point to 30 miles per hour? The housewife looks at the thermometer to see whether she ought to feel too warm or too cold. Even engineers who should be more skeptical have contracted the habit of relying on instrument readings. This naïve faith has in general been justified by the care which the instrument industry has exercised in the control of the accuracy of its products. Nevertheless this great faith in the readings of instruments should continually remind us of the responsibility resting upon us to justify that faith. We have an obligation to promote the correct use of instruments in a manner to secure uniformity and mutual understanding.

Why Measure?

The oldest function of measurement in society appears to have been in the control of the quantity of commodities when sold or exchanged. Such methods were devised many centuries before the Christian era and many of them are referred to in the Bible. As time went on, the quality of commodities became of an importance at least equal to that of the quantity. Every commodity is measured many times and for many characteristics before it reaches the ultimate consumer. Through such measurements the manufacturer maintains the quality of his product, assures its fitness for the intended use, and points the way to its continued improvement. Through measurements the manufacturer, the buyer and the user speak a common language in describing the product, thus promoting fair dealing in daily trade all over the world.

This function of measurement touches the daily life of every citizen.

A second function of measurement is the control of the safe and efficient operation of mechanical and electrical machines and devices. The mastery of heat and power and its control in the service of mankind is the foundation of our industrial civilization. This mastery and control rests on measurement of the pressure, temperature and rate of flow of the steam, the electrical voltage, current and power at the switchboard, the speed of rotating machinery, the stress at critical points in machines, and thousands of similar measurements. The cockpit of a modern aircraft has scores of instruments for measuring the many factors which must be known to assure safety and efficiency. Every automobile has at least the five instruments needed to measure one element of performance of each of the five essential systems, i.e. the fuel supply, the oil pressure, the cooling water temperature, the electric current to or from the battery, and the speed.

This rôle of instrumentation is well-known in the plants producing the many materials and products appearing in trade and commerce. Temperature-measuring devices assure the proper conditions for making satisfactory steel, for cracking petroleum to obtain a desired grade of gasoline, and even for baking bread. Nearly every modern industry has passed from the stage of operations on the basis of the knowledge and experience of skilled craftsmen to the use of accurate instrumentation for measuring and controlling the manufacturing process.

A third function of measurement is to serve as a research tool in the advancement of basic scientific knowledge. I have already referred to Lord Kelvin's appraisal of measurement as a factor in scientific knowledge. Science depends on the recognition and quantitative measurement of identifiable aspects of the physical world. The electrical industry exists because science has learned to isolate and accurately measure various aspects of electrical phenomena. There is an extremely close interrelation of the progress of any branch of science and the status of the art of measurement in that branch. Thus knowledge advances the art of measurement, but likewise advances in the art of measurement accelerate the increase of scientific knowledge. In general, scientific research men are seeking to secure by measurement more basic information or more accurate information, whereas in industry the measurement is a tool to be used in controlling quality. Nevertheless there have been repeated instances of an instrument devised originally purely for scientific purposes finding extensive application in industry, e.g. the optical, infrared and mass spectrometers. Similarly, the wide availability of improved instruments in industry, e.g. the cathode-ray oscillograph, has tremendously accelerated advances in many fields of science.

*Presented at the Spring Meeting of the Instrument Society of America, Cleveland, April 24, 1947.

OUR Guest Editor frequently flies from coast to coast and over the seas; he heads up important activities of numerous scientific and technical societies (Past-President of the Institute of the Aeronautical Sciences, for example). Therefore, hundreds of our readers have seen him and will support our assertion that this picture does not do him justice. The best commercial photographers in Washington had shot a good likeness of Dr. Dryden and we had entrusted it to the best photoengravers in Pittsburgh. Then what happened? Those little dots arranged themselves with malice aforethought to turn his twinkle into a squint and his smile into a frown! In short, the lenses, screens, etchants, etc., conspired to commit the sin of INaccuracy against a famous Priest of Precision who has tended the Temple of Truth (the NBS) since he was twenty years old! Yes, Dryden was born in 1898 in Maryland, received his B.A. at Johns Hopkins in 1916, A.M. in 1918 and Ph.D. in physics and mathematics in 1919. Just before his twentieth birthday in 1918, he was signed up by the NBS. He was made chief of the Aerodynamics Section when he was twenty-two. An adequate record of his pre-war achievements (supersonic-speed airfoils, etc.) would fill this page, so we'll skip to his war-time service as chief of Section 5.1 of the Division of New Missiles of the NDRC where he guided the development of the "Bat" (radar homing missile), receiving for this job the Presidential Certificate of Merit. He worked on numerous committees dealing with guided missiles under the Joint Chiefs of Staff, NACA, Army Ordnance and AAF. His work on the AAF Scientific Advisory Group appointed by General Arnold won him the Medal of Freedom. He is chairman of the Guided Missiles and Pilotless Aircraft Panel of the AAF Scientific Advisory Board and a member of the Guided Missiles Committee of the Joint Research and Development Board . . . and . . . and . . . one heluva good guy!

Underwood & Underwood

—M. F. BEHAR, *Editor*

A fourth function of measurement is the extension of the human senses. While this function is not wholly distinct from the three previously mentioned, this function deserves separate recognition and does cover some applications of instrumentation not related to the other three. Science has long since passed beyond those aspects of physical phenomena perceived by the senses of man. Electricity is perceived only through its physical effects, and all of the knowledge we possess about electricity has been obtained by accurate measurement of these effects. So precise are these measurements that we talk confidently of accuracies of a part in a million.

The war has brought to the public a greater knowledge of recent extension of our sensory powers by physical measurements. Radar, which enables us to see through clouds and darkness at distances up to a few hundred miles, is well-known, although the layman may at first be disappointed in the limited amount of detail available. The use of infrared radiation to permit a more satisfactory vision at moderate distances at night is one of the interesting war-time applications of measurement to a phenomenon not ordinarily perceived by the senses. In the atomic age we are confronted with new phenomena dangerous to human life of which our human senses receive no warning. An instrument, the Geiger counter, fills the gap: it detects these dangerous radiations.

These extensions of our senses by means of instruments were by no means confined to war-time developments. They have been in progress from remote antiquity—from the time of the first device for celestial navigation, through the development of the magnetic compass and of the telescope, down to the present time. The applications to geophysical prospecting for oil and minerals, of precise measurements of the earth's gravitational attraction on a suspended mass, of electric and magnetic anomalies and of times of travel of pressure waves are excellent illustrations of this function of extending the human senses.

What Next?

We are often asked at the National Bureau of Standards when our work on standards of measurement and the problems arising in connection with their application in science and industry will be "completed." Can we not establish the standards of length, mass, time, etc., once for all?

From the remarks already made as to the rôle of measurement in our present-day world, it is obvious that your work and our work will *never* be completed as long as science and technology continue to grow—and there is no reason to expect their growth to cease; on the contrary we are on the threshold of a new age, the age of nuclear energy, and we are in the midst of a period of intensive application of scientific knowledge to industrial processes. Prudent foresight dictates that your activities and ours should be expanded, not contracted.

Some of the trends of development of the field of measurement, as I see them, are the growth in the number of things to be measured and their complexity, the need in industrial and scientific work of more accurate measurements, the remarkable increase in the application of electrical methods to all kinds of measurements, and the beneficial results from interchange and cross-fertilization among various fields of application of instrumentation.

Some few years ago I happened to notice on the floor of our shipping and receiving room at the Bureau an incoming shipment labeled "one quart human breath." This was so unusual a commodity that I inquired about it. It was indeed a sample submitted for test and correctly identified: the breath of a worker in one of the plants of the Manhattan Project to be examined for content of radioactive material. On the same day there were samples of synthetic rubber, of new plastic materials, adhesives, new anti-knock fuels and other materials not in existence a few years before.

There has been a tremendous growth in the number of things on which measurements are to be made, in the number of properties to be measured and in the complexity of the required measurements. Applications of atomic energy will require knowledge of the neutron absorption of materials, a new property to be measured. Since this property may be controlling, materials showing desirable characteristics in this respect will have to have other properties measured, such as their structural strength and rigidity at normal and high temperatures. The number of magnitudes that will need to be measured is ever increasing.

The measurements required are becoming more and more complex in character. Complex equipment has been developed to save man physical and mental labor, which can be operated properly only when its performance and condition are known. Measuring devices must be provided to translate the physical conditions to indications or records which are readily interpreted by the operator. Complexity has led to the development of remote indication so that the measurements of the performance of a whole power plant—or even of a whole electric power network—can be transferred to a single board where one individual can supervise the over-all performance. It is but a step to introduce automatic control of the operation of the plant, to use the pseudo-sensory reactions of the measuring instruments to command control mechanisms until the desired result is obtained to the satisfaction of the measuring instrument.

The trend in our common field of activity is thus to develop robots of great physical power, fully equipped with a highly precise and interlocked nervous system capable of all the activities of the reflex nervous system of man, often of higher precision, and in addition capable of primitive forms of judgment. You are the creators or expert users of these complex systems.

A second noticeable trend is the demand for increased accuracy of measurement in ordinary industrial applications of instruments. Those of us at the National Bureau of Standards are perhaps more keenly sensitive to this trend because it is our duty to try to keep one order of magnitude higher accuracy than that demanded in industry. We have seen the decimal point in industrial length measurements move to the left until accuracies of one ten-thousandth of an inch and one hundred-thousandth of an inch are fairly common. Anyone may purchase at moderate cost a timing device permitting the measurement of time intervals to an accuracy of one millionth of a second. In numerous other fields it is difficult to keep ahead of the demands of scientific and industrial users of the national standards of measurements. One of the reasons why we *do* keep ahead is that you spur us on in so many ways—one way being that you ship us your laboratory standards of mass, length, time, temperature, electrical magnitudes, etc., to be checked against our standards. You probably did not say "How amazing!" but "To be expected!" when you read that the Bureau made and supplied to the armed forces more than half a million pencil-size devices each capable of detecting less than one part of carbon monoxide in five hundred million parts of air.[1]

Through the whole gamut of instruments of all degrees of precision from the more qualitative to the most precise, you who are users are demanding more accuracy under more and more adverse conditions, because you find the higher accuracy economically advantageous. Precise knowledge means in general a more satisfactory product, and less waste of material and manpower.

A third trend is the increasing application of electrical and electronic methods to problems of measurement. The use of these methods permits the meeting of more rigorous requirements as regards sensitivity, accuracy and remote indication. Electrical methods are extremely flexible and adapted to the transfer and amplification of power. Other types of energy supplied by the detector of a physical magnitude are readily transformed to electric energy. As an example of this trend, it is estimated that the number of aircraft instruments using electrical transmission and indication of non-electrical magnitudes increased from less than 5 percent to more than 50 percent between 1935 and 1945.

Electronic instrumentation advanced rapidly during the war but we are just beginning to recognize the possibilities of peace-time applications. The accom-

(1) Anon. "New Indicator Detects 0.000,000,2 % CO." *Instruments*, Vol. 19, Dec. 1946. pages 722-733.

plishment of building a radio transmitter and receiver sufficiently small and sufficiently rugged to be used in a fuze on a shell fired from a gun[2] introduces a new concept of size and ruggedness as compared with that known before the war. My colleagues foresee electronic instruments and controls constituting readily-replaceable rugged units of small size adapted to large-scale mass production by machine methods. Components and techniques already developed include rugged subminiature electronic tubes, miniature capacitors made possible by the development of ceramic materials with high dielectric constant, and the printed electric circuit[3] suitable for mass production of a uniform product at low cost. Some of you may have seen the news report of a serviceable radio transmitter contained in a lipstick case built by the Bureau to demonstrate the application of these developments.

One must of course make a clear distinction between developments that can be completed in the near future and those which will come only after a period of further development. But, looking still farther ahead than the near future, my colleagues visualize applications of measurement and control by electrical and electronic means to the close control of many conditions in industrial processes, involving the continuous measurement of properties of the raw materials and end product, the automatized computation of the requisite adjustments to maintain the desired properties, and the automatic adjustment of the proportions of material and physical conditions to maintain the desired quality. This task is surely no more difficult than that of an automatically-tracking and -computing gunsight which measures the relative motion of a target, predicts its future position, computes the direction of the gun required to hit the target, and moves the gun to that position. The intensive development and use of high-speed electronic computing apparatus provides a background of experience for the further development of such instruments and their application to industrial problems.

In the specific field of sensory elements and transfer devices I should like to mention the wire strain gage. Because of its great importance and wide use, the National Bureau of Standards has made and is continuing to make a study of its accuracy, reliability, stability and general performance as affected by many variables. The principle has been known since Ohm's day but it required the idea of Simmons, Ruge and DeForest of bonding the wire to paper and the presence of modern methods for measuring and recording small changes in current before this principle blossomed out in hundreds of applications. In these applications the strain gage is used as a means of converting a mechanical change to a change in electric energy. By its small size and weight the device has made possible the accurate measurement of many magnitudes under rapidly-fluctuating conditions, in inaccessible locations and in places such as on the surface of rotating machinery. One of the most convenient and accurate devices I know for weighing large aircraft utilizes wire strain gages. This is of course a static application; the dynamic applications are of wide variety and ever-increasing importance.[4]

Another sensory element which I should like to mention is the vacuum-tube acceleration pick-up developed by Dr. Walter Ramberg of our staff. The pick-up resembles an ordinary radio tube but the plates are elastically mounted to deflect in response to acceleration normal to the plane of the plates. This deflection causes a change in plate current proportional to the acceleration. The device has a high output and high natural frequency, making it possible to record rapidly varying accelerations without an amplifier.[5]

The final trend in the development of the art of measurement to be discussed is the growing influence of the cross-fertilization of ideas among various fields. The establishment of scientific and technical journals devoted solely to instruments, the formation of professional divisions of the older technical societies and, particularly, the growth of the Instrument Society of America are the primary factors in this beneficial practice. It may be debatable whether there is such a thing as an art of measurement which can profitably develop apart from some field of science or technology, but there can be no reason to doubt the great benefits of the multiplicity of contacts and exchange of information among those whose primary concern is measurement. Familiarity with work in process in other fields frequently leads to new ideas.

I should like to describe one series of related developments at the National Bureau of Standards which illustrates this process at work. As you perhaps know the Bureau has some sixty specialized sections having contacts with many different industries and types of products; and fortunately there is fairly good interchange of information between them. The story relates to the use of diamonds for various types of measurements. One of the early interests of the Bureau in diamonds was as a tool for ruling lines on precision scales. In connection with this work C. G. Peters and F. Knoop devised apparatus and techniques for cutting diamonds to desired shapes with sharp straight edges free from nicks. When confronted with the problem of determining the hardness of glass and other brittle materials, Knoop and Peters devised an indentation method using a diamond indenting tool of elongated pyramidal form making a rhomb-shaped indentation of length about seven times the width.[6] The tool gives indentations of accurately-measurable length in the most resistant steels with loads of the order of one pound. The use of these light loads permits the extension of indentation tests to small specimens and to tests of brittle materials such as glass which shatter under the heavy loads required by most indentation-hardness testers. The Knoop indenter has been standardized as to dimensions and is the tool used in the Tukon Tester. It has been applied to determinations of the indentation hardness of glass, dental plastics, enamels, porcelains, electrodeposits, thin sheet metal, hardened surface layers on steel, and even to individual particles less than 0.001″ in diameter in polished and etched surface of a specimen of steel. It has made possible measurements of the indentation hardness of tungsten, boron and silicon carbides.

While this development was in progress, H. C. Dickinson and S. A. McKee became acquainted with the indenting tool. They were engaged in studies of the wear of aircraft engine cylinders and were employing the standard gaging methods of measuring cylinder diameter at many places and obtaining the wear as the small difference of two large dimensions: the diameter before and after a certain period of operation. Dickinson and McKee recognized the possibility of measuring small amounts of wear by the change in length of a series of standard indentations of the general shape made by the Knoop indenter. The actual tool used in the Dickinson-McKee wear test apparatus is of somewhat different dimensions. It was soon found that the wear could be measured to a precision of 0.00002″ and that smaller amounts could be detected. The wear occurring in a few hundred starts and stops was readily measurable, including the variation with depth below the top of the cylinder and circumferential position.

Further by-products of the work on diamonds were new methods of cutting diamonds and of drilling small diamond dies used in drawing and shaping extremely hard and fine wire, but these developments are outside the domain of our present subject.

This accelerated interchange of information should be encouraged in every possible manner and should be one of the primary objectives of the Instrument Society of America.

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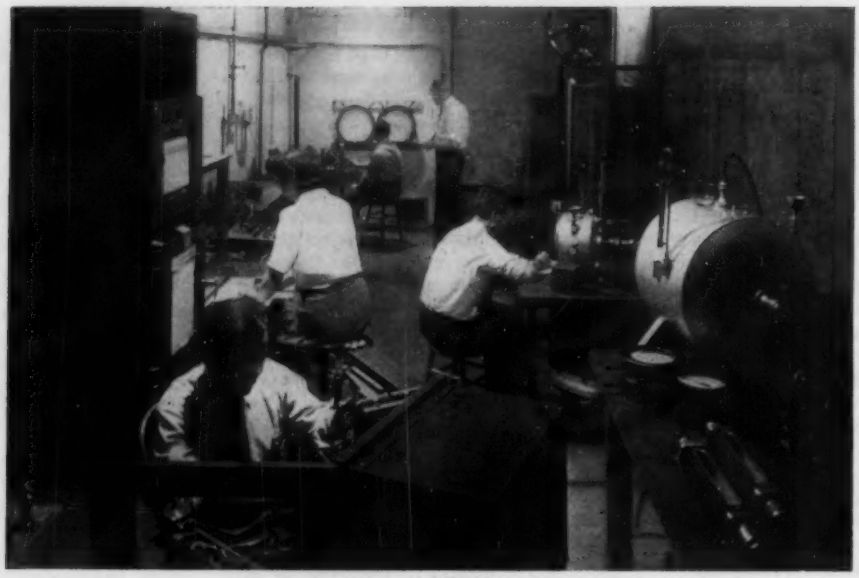
(2) Anon. "Radio Proximity Fuze," *National Bureau of Standards Technical News Bulletin*, Vol. 31, Jan. 1947, pages 3-8 [11 illus.]

(3) Anon. "Printing Electric Circuits," *Instruments*, Vol. 20, April 1947, pages 366-367.

(4) A. V. DeForest, "Characteristics and Aircraft Applications of Wire Resistance Strain Gages," *Instruments*, Vol. 15, April 1942, pages 112-114, 136 137.

(5) Anon. "Vacuum-tube Acceleration Pick-up," *Instruments*, Vol. 20, Feb. 1947, pages 118-120.

[6]F. Knoop, C. G. Peters and W. B. Emerson, "A Sensitive Pyramidal Diamond Tool for Indentation Measurements," *Bureau of Standards Journal of Research*, Vol. 23, 1939, pages 39-61.



Calibrating various types of instruments.

Organization of a Research Laboratory Instrument Department*

By PAUL G. EXLINE, Section Engineer, Gulf Research & Development Co., Pittsburgh, Pa.

So greatly does the instrumentation of a large research laboratory differ in purpose and function from that of a processing or manufacturing unit that the organization of an Instrument Service Department presents many unusual problems. Each laboratory will have problems peculiar to the industry or branch of industry which it serves. The organization of an Instrument Service Department in the Gulf Research and Development Company laboratory is described herein, but it is felt that the structure and operating principles can also be applied to those serving other industries.

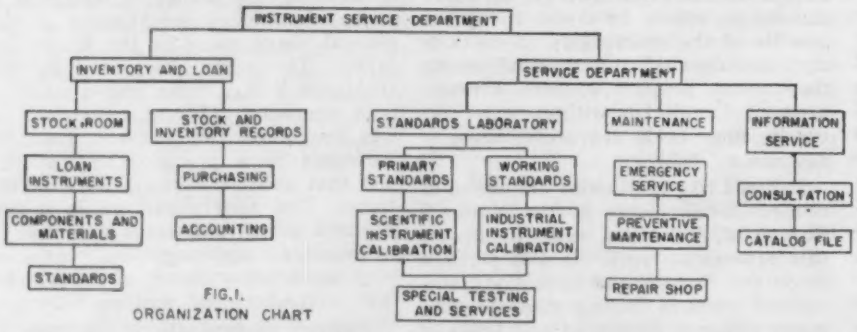


FIG. 1.
ORGANIZATION CHART

The research laboratory is characterized by the wide variety of instruments used and the caliber of the personnel using them. Although it may be departmentalized into a few functional divisions, there are many separate projects of various sizes, each under the responsibility of one or more specialists. This requires that the actual wants and needs of a large number of individuals must be satisfied, and the facilities and personnel of the instrument department must be versatile in the extreme.

The planning of the physical equipment of a refinery or large process plant must include the instrumentation, and a place is made for an instrument service department in the original organization. A research laboratory generally attains stature by a process of more or less gradual growth, and somewhere along the line the need for an instrument department becomes sufficiently acute to be recognized. During the growing period each worker is his own instrument man and, to a certain extent, he must always be so. Aside from the purely theoretical analyses, *almost the entire product of research is data obtained from measurements made with instruments.* The value of the research worker lies in the interpretation he makes of the data and in the measurements he decides are necessary. It is his responsibility that the instrumentation be right and the data correct. However, when the plant becomes large enough, operating economies can result from pooling the purely instrumental duties, and some of the research worker's responsibilities can be delegated to a competent Instrument Department.

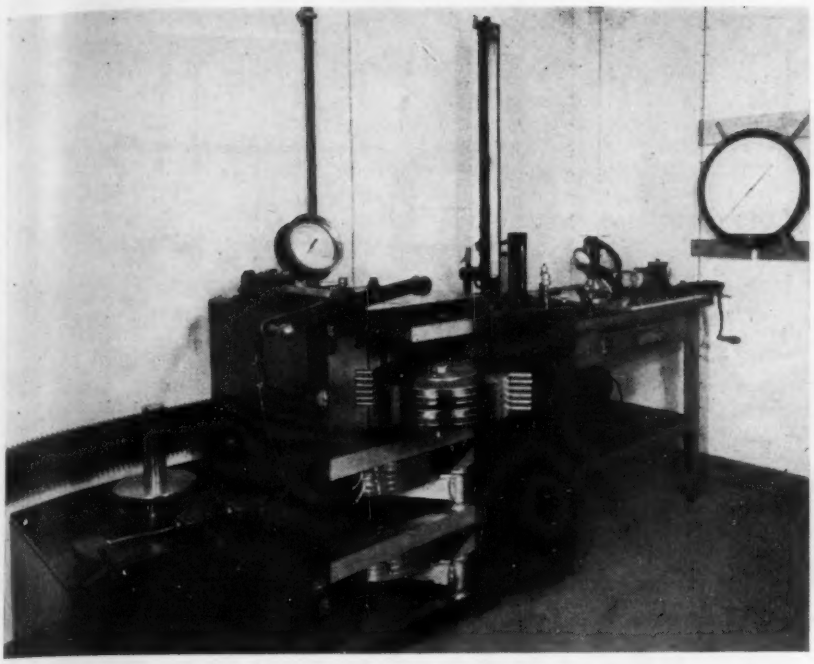
In organizing the Instrument Department, several guiding principles must be adhered to as rigidly as possible:

1. The Department must provide SERVICE: as if it were operating against the keenest of competition.
2. It must stay strictly within its own bounds and not encroach on the territory of the research worker.
3. It must have the confidence and support of those it serves.
4. It must have the confidence and support of management.

The block diagram, Fig. 1, shows the Department divided into two groups: the Inventory and Loan Group which is largely clerical, and the Service Department which is principally of a technical nature. That the two groups and their sub-divisions are closely

*Presented at the first Annual Conference of the Instrument Society of America, William Penn Hotel, Pittsburgh, Penna., Sept., 16-20, 1946.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.



Portion of pressure-gage calibration facilities. 10,000-lb./in.² dead-weight tester in foreground.

interrelated will be brought out as they are discussed individually. The relative size of each subdivision will depend largely upon the size and nature of the laboratory. In some cases the stock room will far over-balance the other groups and maintenance can be almost neglected. In this Laboratory the emphasis is on maintenance and calibration.

Inventory and Loan

This group includes the stock room and its close relative, the inventory record. It should be unnecessary to point out the importance of keeping an accurate record of each instrument and its location. The value of maintaining a well-indexed catalog of library books and a librarian who can locate any book within minutes is universally recognized. That similar control over instruments aggregating many times the value of the library books is economically justifiable can be demonstrated repeatedly. In many cases expensive instruments have been passed through so many hands that hours are lost trying to relocate them. Parts become lost, minor repairs are neglected, and in far too short a time a fine instrument can become virtually worthless.

Various systems are satisfactory for cataloguing instruments; we have found that the Kardex visible index file is adequate for our purpose. A sample inventory card is shown in Fig. 2. On the left-hand side of the card are spaces for the instrument number, its type, range, make, model, serial number, purchase information, location of instructions, and its normal location in storage. On the right-hand side is space for the data of each calibration and the calibration number.

The two bottom lines are the only ones visible as the cards lie flat in the trays. The instrument number, name and range are repeated here for ready reference. Two series of numbers are also visible which are used when the instrument is out of the stock room. The first series corresponds to the days of the month and will tell when the instrument is due for return by slipping a colored marker over that date. Each day the record clerk notes all instruments whose markers are covering that date and calls the borrowers of the instruments. The second series of numbers, 1 to 10, is similarly used to indicate the location of the instrument, a marker over the first number showing that the instrument is on the stock room shelves and available for immediate loan.

The back of the card has space for entering the name and location of the borrower and the date the instrument was borrowed.

If the Department is organized after

NUMBER	TYPE OF INSTRUMENT	L-185
		CALIBRATION
RANGE		
MAKE		
DATE		
MODEL STYLE NO	SERIAL NO.	
SUPPLIER		
COST	REQ. NO	
RATE		
INSTRUCTION INFORMATION		
REMARKS		
STORAGE SPACE		

NUMBER 1 2 3 4 5	DESCRIPTION OF INSTRUMENT 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21	RANGE 22 23 24 25 26 27 28 29 30 31	DEPARTMENTS 1	2	3	4	5	6	7	8	9	10

Fig. 2

Electrical-component calibration and repair bench at left; workbenches for minor repairs in background.

the laboratory has been operating for a considerable time, it is necessary to make an exhaustive inventory in order to set up the index. At this time the identifying numbers are attached to the instruments as they are catalogued. The inventory must be made under the close supervision of one familiar with all types of instruments so that the cards will be filled out completely and accurately. After the system has been set up it must be kept up to date religiously by properly entering each new instrument as it enters the laboratory.

Adequate control can be maintained only if all instruments enter the laboratory through the Instrument Department. This not only gives ample opportunity for securing correct data for the inventory record but also enables the Department to inspect and calibrate the instruments before they are placed in service.

It should be pointed out that it is very important to have a uniform system of naming and classifying instruments so that they may be easily

TABLE I—CLASSIFICATION OF INVENTORY RECORD

Gas Flow & Volume Measurement
- Anemometer
- Dry Gas Meter (75-lb. WP)
- Flowmeter
- Gasometer (2 liter)
- Orifice (adj. thin plate)
- Velometer
- Wet Test Meters
- Rotameters

Length & Position Measurement
- Cathetometers
- Dial Indicators
- Gage, Depth
- Level, Precision
- Micrometers

Mass & Force Measurement
- Balance, Jolly
- Balance, Analytical
- Balance, Heavy Precision
- Proving Ring
- Scales, Beam
- Scales, Spring
- Weights, Precision

Optical Equipment
- Comparators
- Microscope Components
- Microscopes
- Optical Lever
- Prisms
- Refractometer
- Telescopes

Pressure Measurement
- Barometers
- Dead Weight Testers
- Gages, Differential
- Marometers, Absolute
- Manometers, Absolute Zimmerle
- Manometers, Dial
- Manometers, Differential
- Manometers, U-tube
- Manometers, Well Type
- Regulators, Pressure

Speed Measurement
- Speedometers
- Strobotacs
- Stroboluxes
- Tachometers, Absolute
- Tachometers, Autosyn Chrono-
- Tachometers, Chronometric
- Tachometers, Hand
- Tachometers, Indicating

Temperature Measurement
- Thermometers
- Thermostats

Heating Equipment
- Furnaces
- Hot Plates
- Ovens

Time Measurement
- Clocks, Electric
- Stop Clocks
- Timers, Cyclic
- Timers, Interval
- Stop Watches

Gas Detecting & Analyzing
- Carbumeters
- CO_2 Measuring Meters
- Mask, Gas
- Mask, Organic Vapor
- Mercury Vapor Detector
- Methane Detector
- Orsat Apparatus
- pH Meters
- Soil Gas Analyzer

Torque Measuring Equipment
- Balance, Torque Measuring
- Torquemeter

Viscosity Measuring Equipment
- Viscometers
- Viscometer, Mud

Laboratory Equipment, General
- Centrifuges
- Colloid Mill
- Combustion Bomb
- Fans
- Filters
- Lamps, Ultraviolet
- Liquid Separators
- Pelletting Machine
- Speed Reducer
- Shaker
- Stirrers

Electrical Measurement, General
- Microammeters, d.c.
- Milliammeters, a.c. and d.c.
- Millivoltmeters, a.c. and d.c.
- Ammeters, a.c. and d.c.
- Voltmeters, a.c. and d.c.
- Wattmeters, a.c. and d.c.
- Watthour Meters
- Recording Ammeter
- Recording Voltmeters
- Recording Wattmeters
- Circuit Testers:
  - Continuity Meters
  - Ohmmeters
  - Industrial Circuit Testers
  - Volt-ohmmeters
- Growlers
- Insulation Tester
- Bridge Testers:
  - Conductivity Bridge
  - Impedance Bridges
  - Wheatstone Bridges

Electrical Measurement, Precision
- Galvanometers
- Galvanometer Accessories
- Potentiometers, Type K
- Potentiometers, Portable
- Potentiometer Scale Expander
- Resistance, Damping Coil
- Resistances, Standard
- Shunts, Instrument
- Shunts, Precision
- Standard Cells, Portable
- Volt Box

Electrical Accessories
- Capacitors, Decade
- Capacitors, Variable
- Inductors, Self
- Inductors, Variable
- Resistors, Decade
- Rheostats, Motor Control
- Rheostats, Precision Potentiometer
- Rheostats, Slide Wire
- Transformers
- Voltage Regulators

Electrical Test Equipment
- Amplifiers
- Audibility Meter
- Batteries, Storage
- Chargers, Battery
- Demagnetizer
- Dwell Indicator
- Filter, Wave
- Filter, Detonation
- Generators, Signal
- Generator, Square Wave
- Head Phones
- Microphones
- Oscillators
- Oscillographs
- Output Meter
- Power Packs
- Rectifiers
- Vibration Detecting and Meas'g Equip't
- Voltage Divider

Industrial Type Instruments

(205 instruments listed, including in any combination functions of control, indication, and recording)
- Flow Measuring
- Level Measuring
- Knock Meter
- Potentiometers
- Pressure Measuring
- Temperature Indicators (bulb types)
- Temperature Indicators (millivoltmeter)
- Time Measuring and Timers

Small-parts cabinets; record desks; Kardex, etc.

found in the index. One fully-qualified person should be responsible for this in order to avoid confusion. It has been our experience that a straight alphabetical index is cumbersome and easily leads to errors. An outline of the functional classification now in use is given in Table I.

Accounting

The accounting duties of the Instrument Department are relatively simple. Each individual makes out a weekly time card showing the distribution of time on various projects. Time may be charged either against general work in the Instrument Department or against specific research projects for which instrument service is performed. Before the cards are sent to the laboratory Accounting Department the total hours worked on projects in the different operating divisions and the total hours spent on the different classes of work in the Instrument Department are taken off for the purpose of making a monthly report of such time distribution. This serves to give a continuous indication of the efficiency of operation of the Department.

Material and supplies and instruments for stock are purchased against appropriate inventory account numbers depending upon whether or not they are plant items to be depreciated over a period of years. When such materials are taken out for permanent installation or complete consumption, a Material Requisition form shown in Fig. 3 is filled out giving the account number of the project on which they are used. A monthly summary of these charges is sent to the Accounting Department for crediting to the inventory accounts.

The same procedure is followed in giving credit for instruments returned from installations—instruments which had been expected to be out permanently.

No charge is made for instruments or equipment taken out for short-time loans except for the time necessary to restore them to first-class condition after use. For this reason the Instrument Department always operates at a loss which represents an overhead charge on all the operating divisions of the Laboratory. A rental charge could be computed for each instrument which would include all factors such as expected life, calibration cost, clerical overhead, etc. The bookkeeping involved in such a system could not be economically justified as the gain in more accurate allocation of project costs would be hardly perceptible.

Stock Room

The facilities of the stock room should be adequate for storage of all instruments which may be in stock at a given time. Too-crowded storage shelves result in loss of time and occasional damage. All cabinets and shelves should be plainly numbered so that the stock clerk need not rely on memory for quickly locating an instrument.

If the Instrument Department is organized after the laboratory has been in operation for a number of years, there will always be found some individuals who have a proprietary interest in the instruments they have purchased themselves and who are reluctant to relinquish such instruments to the general stock room. Such prejudices can usually be overcome when those involved can be assured that the instruments will be kept properly and will be available when the need arises. It is quite important that such assurances be scrupulously kept. It is not infrequent that lack of an instrument can cause a loss of time amounting to more than the value of the instrument.

It is also necessary that the research worker inform the Department of his needs as far in advance as possible so that arrangements can be made to secure the proper equipment.

The stock room must provide instruments for such a wide range of applications that a thorough study of the needs of the laboratory is an essential prerequisite to its establishment. Before a purchase order is written, the frequency of requests for special instruments should be integrated over a period of time and those interested consulted regarding probable future uses.

When an instrument is borrowed, the date and the name and location of the borrower are entered on the back of the inventory card. The date marker is shifted to indicate the expected time of return and the location marker moved to the position indicating the building or section to which the instrument is taken. Upon return of the instrument, the stock-room clerk makes the appropriate notations on the record card and turns the instrument over to the Service Department for examination and calibration. Any work done on the instrument is charged against the project on which it was last used. It is then returned to its proper place on the shelves.

Components and Materials Stock

In a research laboratory many temporary and permanent experimental set-ups are fashioned by the workers. The "string and sealing wax" of the traditional experimental physicist must be supplemented by a wide variety of

INSTRUMENT SECTION COPY

L-202 No.

MATERIAL REQUISITION

PROJECT _____ DATE _____

QUAN.	DESCRIPTION	COST

SIGNED _____

Fig. 3. Material Requisition Form, made out in triplicate, one copy being used for monthly summaries.

L-212

INSTRUMENT SERVICE REPORT _____ NO. _____

FROM _____ DATE _____

TO _____ PROJECT _____

INSTRUMENT IDENTIFICATION _____

LOCATION _____ SERVICE REQUESTED BY _____

WORK REQUIRED _____

_____

_____

_____

_____

_____ HOURS _____

CAUSE OF TROUBLE _____

_____

_____

PREVENTIVE MEASURES _____

_____

NOTED BY _____ RETURNED _____

Fig. 4. Instrument Service Report Form, made out in duplicate, retained copy being used for periodical analyses.

materials which are readily available. Some of these are truly instrument components but many others might fall into the gadget class. A list of such items is shown in Table II. It is debatable whether some items properly belong in an Instrument Department and many laboratories will carry a number of such items in their general stock room.

The records of the components and materials stock are also kept in a Kardex visible index file. Each card has the name of the item and its cost typed along the bottom edge where it is visible as the cards lie flat in the trays. Space is provided for entering the maximum and minimum number of items which should be carried in stock. The date of removing one or more of an item is entered on the card and the number removed subtracted from the number previously shown to be in stock. When this falls below a minimum number shown on the card, enough additional items are ordered to bring the stock back up to the maximum number.

TABLE II
COMPONENTS AND MATERIALS STOCK

Stock Class	Number of Different Items
Adapters, Loktal	3
Aluminum Sheet Stock (0.003"-0.005")	2
Batteries, Dry Cell	13
Bearings, Miniature Ball	12
Binding Posts	3
Bulbs (pilot light & special application)	38
Cable	8
Capacitors	50
Ceramic Tubing	15
Chart Paper	26
Chassis & Boxes	7
Clamps, Battery	9
Clamps, Cable	4
Clamps, Tubing	10
Copper Mesh Screen	3
Counters	8
Electric Indicating Instruments	45
Electrical outlet sockets, plugs, cable connectors, etc.	91
Flasks, Dewar	1
Fuses & Fuse Holders	46
Grid Clips	3
Grommets	8
Handles, Ball Crank	1
Heaters	25
High Pressure Fittings	8
High Pressure Fitting Tools	3
Inks, Recorder	15
Instrument Feet	1
Insulation, Asbestos	1
Lamps, Misc.	2
Oils, Industrial Instrument	2
Oscilloscope Tubes	3
Paint, Temperature-Indicating	12
Pilot Lights	18
Radio Tubes	78
Relays	47
Resistors	164
Spaghetti (Insulation)	11
Switches	42
Switches, Mercury	8
Tape, Asbestos	1
Tape, Friction	1
Tape, Glass	4
Tape, Rubber	1
Terminal Strips	7
Thermocouple Wire	26
Thermometers	28
Tubing, Asbestos	1
Tubing, Woven Glass	6
Valves, Hoke	4
Valves, Magnetic	1
Variacs	5
Vibration Dampers	1
Wire, Heater	6
Wire, Hook-up	35
Service Stock—Parts and Accessories for:	
*Brown	20
Esterline Angus	1
*Foxboro	8
*Leeds & Northrup	35
*Mason-Neilan	20
Sun-Timing Light	6
*Tagliabue	25
Wet Test Meters	11
TOTAL ITEMS	1094

*Includes several range changes.

A Material Requisition form, shown in Fig. 3, is also filled out, in triplicate, at the time of removal of material stock. The unit cost of each item is looked up in the visible index and the total entered on the form before it is removed from the register. One copy is given to the person signing for the material, one copy is sent to his section head, and the third is used for making out the monthly summary of project charges for the Accounting Department.

SERVICE DEPARTMENT

The Service Department is divided into three highly important and specialized groups: the standards laboratory, the maintenance group, and the information service.

Meter prover set up for rotameter calibration. At right, precision 2-liter gasometer.

Standards Laboratory

It is the function of the standards laboratory to maintain an adequate supply of primary and secondary standards, and facilities for using them, so that any instrument can be checked to the required accuracy. It was mentioned before that the principal products of a research laboratory are data obtained through the use of instruments. The utmost importance is attached to the knowledge of the accuracy of the measurements in interpreting their meaning. Table III gives a list of the standards which are regularly used.

Little emphasis is given in this list to length standards. This Laboratory maintains a large instrument shop of unusually high standards. This shop maintains an inspection department with length standards sufficient to cover a wide range of dimensional inspection. For this reason it is unnecessary to duplicate such equipment in the Instrument Department.

The facilities of the standards laboratory should be such that permanent calibration-stands are available for the more frequent services. In this Laboratory this includes calibration of pressure gages, gas meters and flow-rate indicators, thermometers, thermocouples, large precision weights, a-c and d-c. electrical instruments and resistors. It is hardly necessary to describe these facilities in detail. Descriptions of precision calibration equipment of various types can easily be found in the literature and in manufacturers' catalogs.

Occasionally the facilities of the standards laboratory may be required in research work which cannot be easily done elsewhere in the Laboratory. This is especially true where constant temperature conditions are required. Special arrangements can usually be made for such work when it is of such a nature as not to interfere with the routine work.

Instrument Maintenance

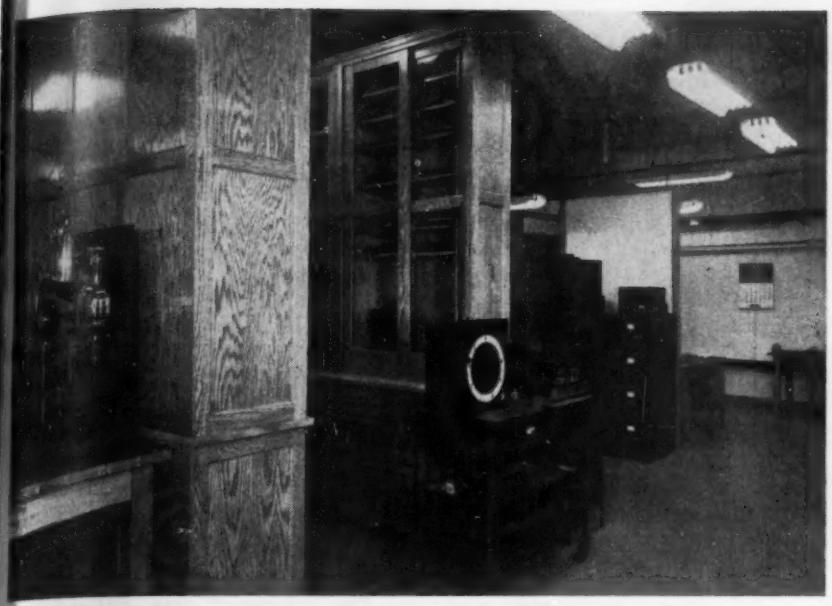
Because of the nature of this Laboratory, it is necessary to maintain extensive pilot plant operations and new process development where the instrumentation problems are similar to those of a refinery. Unlike a refinery, failure of an instrument can result in much more than product spoilage; it may cause the loss of a test involving thousands of dollars in labor and materials. For this reason an emergency instrument service must be available at all times.

Providing service only to those instruments giving trouble is an expensive and uneconomical procedure. All installed control and recording instruments should receive the benefits of a well-planned preventive maintenance program. This will not only minimize the emergency service required but will do much to minimize the possibility of loss of expensive tests.

The maintenance program should provide for periodic attention to all installed instruments. This includes general inspection, battery replacement, replacement of worn parts, and inspection of installation conditions. By keeping records of all service calls to instru-

TABLE III
PRIMARY AND SECONDARY STANDARDS

1. *Mass*
   - Class B standards from 0.5 lb. to 20 lb.
   - Analytical weights, 10 mg. to 100 g.
   - Precision balance, 25 kg. capacity
   - Laboratory balance, 1.5 kg. capacity
2. *Length*
   - Precision cathetometer, 1-m. range
3. *Force*
   - Morehouse proving ring, 50,000-lb. capacity
4. *Pressure*
   - 10,000 lb./in.2 piston gage
   - 2,000 lb./in.2 piston gage
5. *Gas Volume*
   - 5 cu. ft. meter prover
   - 0.1 cu. ft. bottle
   - 0.15 cu. ft. gasometer
   - 2 liter gasometer
6. *Thermometric*
   - Set of certified thermometers covering range from —60°F. to 600°F.
   - Mueller bridge and resistance thermometer
7. *Pyrometric*
   - Platinum-platinum rhodium thermocouple with precision potentiometer
8. *Electrical*
   - Standard cells
   - Resistors
   - Precision d-c. potentiometer with volt box
   - Certified a-c. ammeter and voltmeter
   - Anthony bridge



Portions of storage facilities and of office space.

ments the proper frequency of attention for the different applications can be determined.

Emergency service generally follows a call for assistance by one of the operators. Such a call will usually be taken by the record clerk who will enter the necessary information on the Instrument Service Report form shown in Fig. 4. This is then turned over to the service engineer who completes the form after correcting the trouble. This form is made out in duplicate with the carbon copy on cardboard retained for periodic analysis to determine most frequent causes of trouble, types of instruments giving the most difficulty and to provide a basis for improving the maintenance service. The first copy is sent to the Section Head having jurisdiction over the instrument serviced, in order to keep him informed of instrument performance and to help him maintain efficient operation.

In experimental pilot plant operation relocation and change of instruments is much more frequently done than in a process plant. This should always be done by or under the supervision of the Instrument Engineer. This course permits correct installations from the start and insures use of the correct instrument for each application.

Coöperation between the chemical engineers and operators and the Service Department cannot be overstressed. On the one hand, competent service must be available when needed, since good service will keep operators from trying to fix the instruments themselves. On the other hand, the operator having confidence in the service will call for help at the first symptom of trouble, not after he finds that he cannot effect the repairs himself. If this is attempted, the damage done by unskilled efforts is often worse than the initial trouble.

Particular attention must be paid to the dividing lines between the work of the instrument service man and that of the pilot plant operators and their supervisors. Primarily, it is the duty of the engineers and chemists to specify the instrumentation and its installation, while the instrument service man must accept the responsibility of its subsequent successful operation. There are many special conditions and nonstandard applications that make this divided responsibility necessary. This places a heavy burden on the instrument service man—not only on his technical ability but upon his tact and diplomacy. While his duties are restricted to the instrument itself, he must know good installation practice and its relation to control of various processes. He must be ready at all times to advise the operators on how best to fit the installation to the process.

Repair Shop.—An elaborate repair shop will rarely be necessary. Because of the great range of instruments used, it is not economically justifiable to set up facilities and develop skills for major repairs on all of them. All such work can be much better done by the manufacturers. Occasionally, where large numbers of a single type of instrument are used, it may be of value to make provisions for more extensive repair and overhaul work. As an example, this Laboratory uses large numbers of wet test meters, many of them under conditions which are extremely deleterious. Arrangements were made with the machine shop for them to send a machinist to the manufacturers' shops to learn the correct overhaul and repair procedures. Now, when the Instrument Department discovers such a meter in need of repair, it is sent directly to the machine shop for a complete overhaul, thus limiting the work of the Instrument Department to inspection and calibration. This arrangement permits the work to be done by an experienced shop man who has available all the tools of a fully-equipped machine shop. An attempt to do this in the Instrument Department would require a large investment in equipment which would be idle most of the time.

Information Service

A consulting service is available for assistance in all matters pertaining to instruments. This includes basic information on the applications and limitations of instruments, assistance in specifying instruments for particular applications, providing data on the properties of various materials, and the like. Because of the large number of individuals, this service requires a surprisingly large amount of time. Much of it is purely educational and must be repeated over and over to individuals applying similar techniques to different problems in various divisions.

An excellent educational opportunity can be secured by issuing occasional technical bulletins describing in simple terms the applications, scope and limitations of instruments and components. The need for such bulletins can be seen from the amount of duplicated questions coming to the service group. They can be directed to all those known to be interested and a stock kept on hand for future use.

A complete catalog file is maintained to make available current information on all instruments and related supplies. Contacts must be kept up with local suppliers and possible delivery schedules carried in mind.

This work requires a thorough knowledge of instruments and the ready availability of a complete reference library to supplement the catalog information.

It is necessary to limit the field of consultation since, in many cases, it could develop into specialized work well beyond that lying within the field of instrumentation service. For example, a request for information on electrostatic voltmeters should not require an investigation of the application to determine the influence of current drain to the voltmeter on the behavior of the device. An accurate and complete description of the available voltmeters should be sufficient. As a general rule, consulting engineering should be avoided while adhering strictly to instrument service.

Conclusion

An attempt has been made to outline the salient points of an Instrument Department in a research laboratory without much description of facilities or discussion of the problems involved. The operations of a research laboratory are quite different from those of a process plant and the Instrument Department must be organized to cope with these differences.

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Requirements for Dynamic Test Equipment in Certain Aircraft Applications*

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THIS article concerns those requirements for dynamics test equipment which have been established primarily on the basis of performance of this type of equipment under service conditions. The requirements are not listed explicitly but are indicated in a general way by a discussion of the limitations of present equipment utilized for aircraft dynamic testing. To indicate the steps taken to obtain improved equipment an approximately chronological outline will be presented of the development and procurement of dynamic test equipment for use by the Flutter Unit, Dynamics Branch of the Aircraft Laboratory of the Air Matériel Command. Responsibilities of this unit include the measurement of two different types of phenomena, namely: flutter oscillations and impact loads, pertaining to aircraft structures and components. Aircraft structural oscillations measured in flutter testing have a definite period but have amplitudes which vary as a function of time such as damped oscillations (transients) and unstable oscillations in which the amplitude increases with time finally reaching a steady-state amplitude or causing structural failure. Impact loads on the other hand consist of a combination of transients of different periods plus static phenomena such as strains and accelerations in aircraft structures during landing, cannon-recoil loads, pressure pulses in hydraulic systems and glider tow loads.

The original responsibility of the Flutter Unit, as indicated by the name, was primarily flutter prevention. In the conventional aircraft structure, flutter oscillations have frequencies which are generally in the range from 3 to about 40 cps. while the amplitudes encountered in "safe" tests vary from about 0.03" at the high frequency to 2" or 3" at low frequencies.

The type of equipment commercially available at the start of the experimental flutter program was not suited for the work. This equipment consisted of velocity pick-ups with natural frequencies of about 7 cps., integrating amplifiers having a proper frequency characteristic from 3 to about 2000 cps. and a 4-channel recording oscillograph with elements having natural frequencies of approximately 2600 cps. The primary limitation of this equipment lay in the pick-up units whose characteristics were questionable over the lower part of the frequency range of flutter oscillations. The amplitude limitations of the pick-up, friction in the support of the seismic system, transient responses of the seismic system and large static deflections of the seismic system in acceleration fields were undesirable features for flutter testing.

For these reasons a cantilever-beam-type fluid-damped strain-gage accelerometer was developed for use with this equipment in conjunction with a single-stage preamplifier. The accelerometer circuit consisted of two 15,000-ohm wire strain gages (measuring the beam bending) excited by a 90-volt B battery with the common strain-gage connection coupled to the preamplifier by means of a capacitor (Fig. 1). This

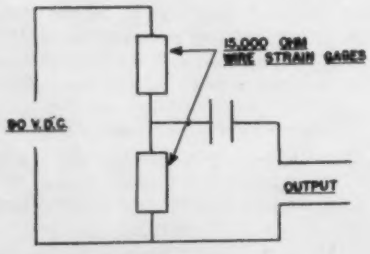

FIGURE 1
STRAIN-GAGE ACCELEROMETER CIRCUIT

equipment was found to be reasonably satisfactory but had the following disadvantages:

The accelerometers had to be calibrated before and after each test in order to insure that the cement bond of the strain gages was satisfactory. (In most cases the calibration factors remained constant over long periods of time). In addition, temperature had an appreciable effect upon the response of the accelerometer despite the fact that the viscosity-temperature curve of the fluid used was reasonably flat.

The recording oscillograph also gave some trouble: bubbles of the galvanometer damping oil often formed in front of the galvanometer mirrors as a result of temperature change and the resistances of the galvanometer fuses changed appreciably, reducing the galvanometer current. The first of these difficulties was inherent in the galvanometer design since the damping oil surrounded the galvanometer mirror. The second problem was important because of the low resistance of the galvanometer and was caused by temporary overloading of the galvanometers. This overloading could not always be avoided by proper setting of the gain control in view of the amplitude-time characteristic of flutter oscillations. The use of a neon overload indicator in this equipment was of considerable help, however, in setting the gain controls and is an excellent feature.

In order to obtain more satisfactory equipment, contracts were let for the procurement of carrier equipment with reluctance type magnetically-damped accelerometers and magnetically-damped galvanometers. The equipment included circuits for single and double integration of the accelerometer output to give vibration velocity and displacement respectively. These circuits were considered important because high-frequency vibrations of small amplitude caused by the engine, propeller, and airflow often cause accelerations of the same order of magnitude as low-frequency oscillations encountered in flutter testing. Performance data for this equipment were approximately as follows:

(a) 4" record amplitude per g acceleration—flat from 0 to 35 cps.

(b) 300" record amplitude per inch displacement—flat from 1½ to 35 cps.

The equipment was unfortunately very bulky, being approximately 1600 in.^{3} in volume and 32 lbs. in weight per channel (excluding the oscillograph). While it gave satisfactory results in some tests, certain troubles were encountered, many of which were inherent in the detail design. Some of these were:

(a) Failure of internal accelerometer structure when accelerometer was installed on an engine.

(b) Oscillator voltage drift.

(c) Poorly damped low frequency oscillations in the integrating amplifier stages.

(d) Ghost traces in the oscillograph caused by the use of two lamps.

(e) Blackening of the oscillograph lamps caused by overheating and resulting loss in light intensity.

(f) Oscillograph paper jams.

(g) Difficulty in adjusting galvanometer positions and timing system.

The low-frequency response of this equipment when used for displacement measurements, in combination with the poorly-damped amplifier oscillations, was disadvantageous for flight tests since motions of the aircraft as a rigid body resulted in larger record amplitudes than those caused by the oscillations in flutter tests. Another disadvantage was the use of plug-in cans for holding circuit components. These cans made it difficult to locate and repair troubles which were encountered and to modify the characteristics of the equipment for meeting requirements of special tests. Since only one set of equipment was procured, it was not considered economical to stock spare plug-in cans.

In view of the need for smaller and improved equipment, it was necessary to revise the basic requirements. These changes were as follows:

(a) The displacement sensitivity was reduced to 60 inches per inch.

(b) The flat frequency range was changed to 5 to 60 cps. on displacement and 0 to 60 cps. on acceleration.

(c) The use of fluid damped accelerometers was permitted to obtain higher natural frequencies and greater sensitivities. Magnetic damping was not practical with the heavy seismic masses and stiff supporting springs used.

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NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

As a result, the volume and weight of equipment procured in accordance with the revised specifications were only 340 in.^{3} and 12 lbs. respectively per channel, excluding the oscillograph. This equipment proved more satisfactory than the preceding type but also gave trouble, the more serious being:

(a) Unbalance of the accelerometers caused by distortion of the case when the accelerometers were attached to rigid structure.

(b) Variation in the accelerometer performance with temperature; the sensitivity was reduced by a factor of 3½ at 2400 rpm. when the temperature was changed from 79°F. to —20°F.

(c) Failure of the accelerometer external leads which were relatively fine wire covered by thin insulation (rubber covered shielded cable gave no trouble in the preceding equipment).

(d) Zero drift of the accelerometer equivalent to about 0.3 of a *g* per 25°F. change.

(e) Failure of accelerometer internal leads when installation was made on an aircraft engine.

(f) Oscillograph paper jam.

(g) Oscillograph timing system failure when B-battery was used. (B-battery was later replaced by a vibro-pack).

The troubles experienced with the above types of equipment can be largely rectified by more emphasis on detail design and recognition of the necessity for ruggedness and dependability in aircraft test equipment, particularly in accelerometers.

In addition to the advantage of small weight, the smaller equipment had an improved system of demodulation in the amplifier. The original equipment used a straight carrier injection scheme (Fig. 2) after the gain control so that a d-c. voltage is imposed on the galvanometers and has to be balanced out. In addition the injected voltage has to be in phase with the signal voltage or the output will not be a linear function of the signal. The later equipment used two half-wave detectors arranged so that the output was the difference of the detector outputs (Fig. 3). The voltage on one detector is the sum of one-half the injected voltage plus the signal voltage while that on the other detector is the difference between one-half the injected voltage and the signal voltage. With no signal there is thus no output and in addition the quadrature component of the signal voltage gives no rectified signal output since the output voltage reverses during each half-wave. Thus, the quadrature component of the bridge voltage does not have to be balanced, permitting the use of a single bridge balance control unless the phase unbalance overloads the detector and/or preceding amplifiers. Moreover the injected voltage does not have to be exactly in phase with the signal voltage for linearity, the only effect being a reduction in sensitivity. This type of rectification is now a requirement on all carrier equipment with the modifications that:

(a) Full-wave rectification with copper-oxide or selenium rectifiers and transformer inputs are required for increased power.

(b) A screw-driver phase balance control is incorporated in the bridge to reduce phase unbalance when necessary.

(c) The phase of the injected voltage is controllable to insure maximum sensitivity with all types of pick-up units.

Some of the more fundamental difficulty experienced with the equipment described above did not affect the accuracy obtained in flutter tests. The explanation lies in the fact that the only flutter data which need be measured accurately are: the relative amplitudes of vibration of the various components involved, the relative phase relationships and the flutter frequency. Since flutter oscillations take place at a definite frequency, the only basic requirement for accurate data is that all channels of the equipment have the same frequency and phase shift characteristics. The major source of error in flutter measurements proved to be the "hash" on the records caused by engine, propeller, and airflow disturbances. In practice it was found that the use of an integrating circuit was a satisfactory solution to the hash problem.

The accuracy of the results obtained with the above type of equipment in impact load testing was less satisfactory. In this type of testing, absolute magnitudes and wave shapes are important data so that the frequency and phase shift characteristics must be given more consideration. Reasonable requirements for such equipment are a flat frequency response plus proportional phase shift from zero to the highest frequency component to be recorded and about 0.7 critical damping for all seismic systems. The important frequencies in various types of dynamic tests were found to lie in the following ranges:

(a) Landing load tests—below 20 cps.
(b) Pressure pulse tests—below 100 cps.
(c) Cannon recoil tests—below 200 cps.

(In the cannon recoil tests, a pulse was recorded which had a period of about 70 milliseconds and the frequency was estimated on the basis of the slope of the beginning of the pulse.) The need for a response to zero frequency is based on those cases where a combination of static plus dynamic phenomena are to be measured such as in landing load and hydraulic tests. When the complete phenomenon is over in a relatively short period, a zero frequency characteristic is not required. However, there will be superimposed on the signal voltage an output caused by discharge of capacitors and loss of d-c. flux from transformers if there is appreciable phase shift in the equipment at the lowest frequency to be recorded. Another effect which has occurred is the excitation of very-low-frequency transients (damped motorboating oscillations) in the amplifiers. These transient effects are not too serious if their period is long compared to that of the pulse.

The problem of phase shift or time delay in dynamics measuring equipment has been the subject of considerable discussion. For steady-state oscillations this time lag is not a serious problem since the wave-shape reproduction will be perfect as long as all frequency components are reproduced with the same time delay and same magnifications. The first condition is obviously satisfied by a phase shift proportional of frequency. Under transient conditions, the effect of phase shift is to distort the shape of the beginning and end of the pulse by transient vibrations of the pick-up unit and galvanometer which will prove serious if there is insufficient damping in the seismic systems. Consider for example an acceleration pulse made up of half of a sine wave of such a frequency that there is considerable phase shift between the applied acceleration and the pickup response under steady state conditions. At the start of the pulse, the steady state condition requires finite values for the velocity and displacement of the seismic elements of the accelerometer and galvanometer, while actually these values

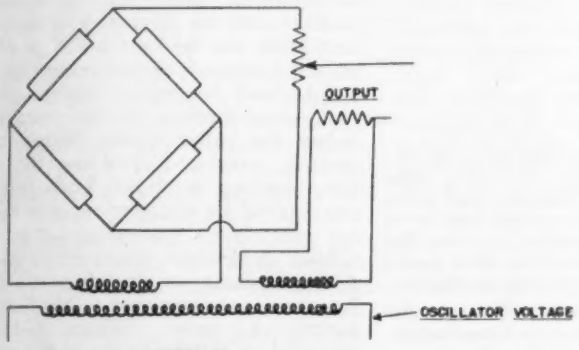


FIGURE 2
A.C. BRIDGE WITH CARRIER INJECTION

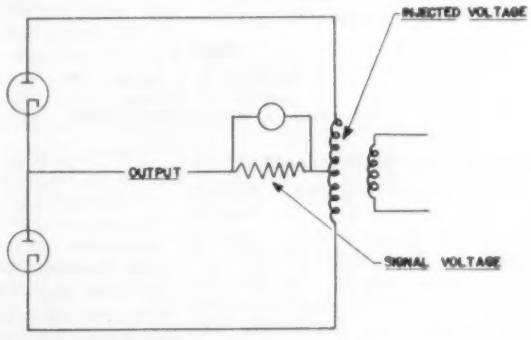


FIGURE 3
PHASE DISCRIMINATING DETECTOR

must be zero. To satisfy this latter condition there is superimposed on the pulse free vibrations of the seismic elements (Fig. 4). (Free vibrations also occur at the end of the pulse because of energy left in the seismic system). However, with seismic systems having approximately 0.7 critical damping, the peak transient response and peak steady-rate response do not differ appreciably in magnitude from the peak static response even when the frequency of the half sine wave pulse equals the natural frequencies of the seismic systems. However, under this condition, the steady-state vibratory response is only 70% of the static response so that it usually is not advisable to operate at frequencies above half the natural frequencies of the seismic systems. The only difference between the transient and steady state vibratory responses will then be a slight distortion of wave shape under transient conditions. If however, the damping is considerably less than 0.7 critical, appreciable trouble can be expected in transient measurements (Fig. 5).

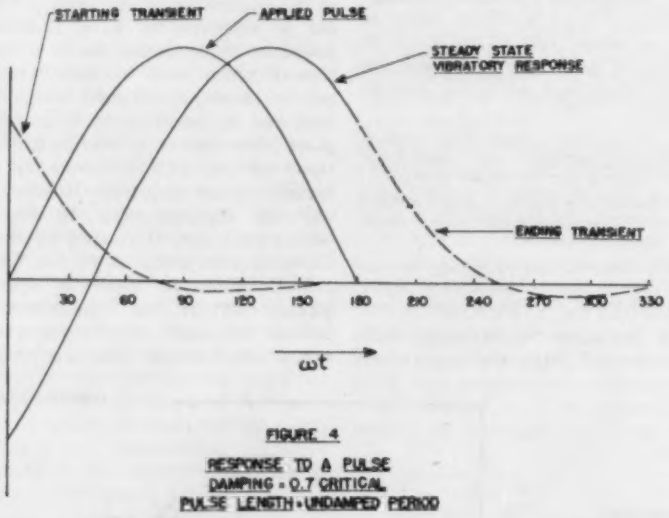


FIGURE 4
RESPONSE TO A PULSE
DAMPING = 0.7 CRITICAL
PULSE LENGTH = UNDAMPED PERIOD

The carrier type of equipment procured for flutter testing had a sufficient frequency range for the measurement of landing load phenomena such as landing-gear loads, acceleration of structural components, and structural strains. In addition, the range of the accelerometer units used for flutter testing ($\pm 15\ g$) was adequate for most of the measurements desired. In order to make full use of the equipment, it was only necessary to make modifications required for strain-gage applications. For the first type of equipment, the modifications required were an increase in gain and a change in the phase of the injected carrier, while in the second type of equipment it was only necessary to increase the gain. The resulting strain sensitivity in both cases was of the order of one-inch record amplitude for a strain of 250 microinches per inch.

The functioning of the equipment in actual landing tests was generally satisfactory even though certain problems showed up. These problems were:

(a) Hash on the accelerometer records caused by unimportant accelerations such as local structural vibration and engine propeller vibration. Low-pass filters having a cutoff at around 20 cps. were finally used to reduce the hash level coming from accelerometers located near the engines.

(b) Drift in the strain-gage channels. The drift was slow enough so as not to affect the accuracy of the data but was objectionable in that the equipment had to be continually rebalanced during the test. For tests in single-place aircraft, drift cannot be tolerated if it overloads the equipment.

(c) Stopping of the timing galvanometer in one oscillograph during hard landings.

(d) Difficulty in adjusting the gain controls to prevent crossing of the oscillograph traces in many records thus making it extremely difficult to identify the traces.

In one series of landing tests, a large number of channels of equipment had to be used to obtain the desired data. Actually 37 channels of equipment were used with four separate oscillographs. Upon analyzing the data, it was found to be very difficult to synchronize the records of the various oscillographs even though a synchronizing pulse was employed in each unit. The timing lines in the various oscillographs were not sufficiently accurate to permit synchronization from the single pulse and it was necessary to calibrate each timing system and correct for the differences which were of the order of 2% to 3%. The use of four oscillographs also resulted in somewhat of a personnel problem in that it was necessary to have three flight engineers to make sure that:

(a) All units were operating properly, i.e. that the oscillograph paper did not jam and the bulbs did not burn out.

(b) Drift in strain-gage channels associated with a particular oscillograph was balanced out and gain controls were set properly.

The obvious solution to the above problems was to have an oscillograph developed with 37 or more channels. There are on order now some 34-channel oscillographs with means for synchronization by operating the timing systems from a common oscillator or by a continuous synchronizing pulse. In order to make the oscillographs small enough for aircraft use, the trace amplitude will be kept below one-fifth of an inch and optical magnification will be used for record analysis. With such magnification, it was possible to reduce the paper speeds, thereby conserving paper and obviating the need for reloading in flight. These oscillographs will be equipped with a means for identifying traces, probably consisting of a light interrupter successively blacking or dimming the light from each galvanometer. Other features include a paper footage indicator operated by motion of the paper rather than motion of the driving rollers and an indicating light which will blink when the paper is in motion.

About the time the landing load test program was under way, the problem of measuring glider towing loads came up. This measurement differed from landing load measurements in that the equipment had to remain in balance during the entire test (about 2 hours) whereas for landing measurements the equipment could be rebalanced before the landing impact and had only to remain in balance for a few minutes. Ex-

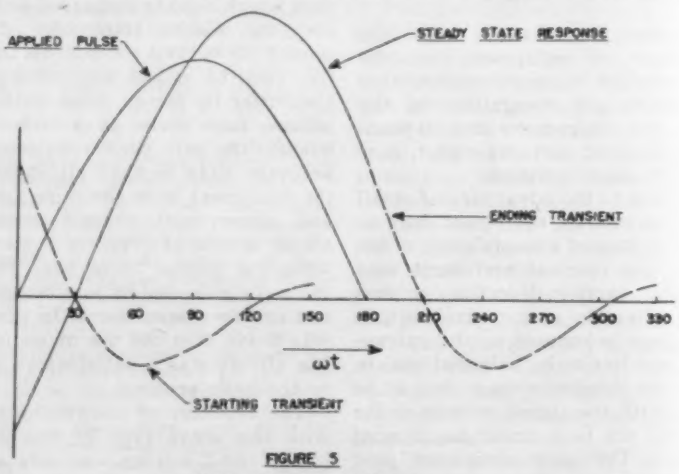


FIGURE 5
SAME AS FIGURE 4 EXCEPT
DAMPING = 0.35 CRITICAL

perience with carrier equipment indicated that it would not be suitable for such measurements because of its drift under flight test conditions. Fortunately, some 40 cps. galvanometers were on hand at the time which had sensitivities of around one-inch record amplitude for 30 microamperes input and thus these galvanometers could be operated directly by a d-c. strain gage bridge. With a four-active-arm 120-ohm strain gage bridge excited by 12 volts d-c., one-inch record amplitude was equivalent to a strain of 200 microinches per inch. This equipment gave excellent results in the glider tow load test, the only source of error being a thermoelectric current of about two microamperes. In fact, the operation was so satisfactory that it was decided to make use of d-c. bridges for all low-frequency and static strain measurements. It was recognized, of course, that the strain gages could not be used at full gain for landing tests because the low resistance provided too much electrical damping for the galvanometers employed.

The first attempt to use this equipment for landing tests ended in failure because of vibrations of the galvanometers caused by the landing impact. This problem was partly solved by mounting the oscillograph on shock cord. Later, an investigation was conducted regarding the response of galvanometer elements to landing impacts and it was found that the average single-vibration amplitudes of oscillograph elements per g of landing acceleration were:

(a) 0.3″ for 40-cps. elements.
(b) 0.2″ for 60-cps. elements.
(c) 0.1″ for 100-cps. elements.

All of the above readings were made with the oscillograph mounted on its regular base.

Fortunately, improvements have been made in oscillograph element design so that 160-cps. elements will soon be available having sensitivities of the same order of magnitude as the 40-cps. elements. The high frequencies of the elements will obviously reduce the effects of external acceleration as well as provide a wider frequency range for the measurements. The use of these galvanometers with d-c. bridges appears to be the most practical means of conducting aircraft structural flight tests, assuming the errors caused by thermal emf's are no larger than mentioned above. In order to minimize these errors the gain controls on the d-c. bridges being procured are specified as series and parallel bridge output resistances rather than resistors in series with the d-c. voltage. The latter method is simpler but does not reduce the thermoelectric current. A feature to be incorporated in the d-c. bridges is a balancing indicator since it was not convenient to balance by observing the galvanometer spots.

The d-c. bridge method of strain gage measurements will not cover all the needs of an aircraft dynamic test group. Hydraulic pressure, aerodynamic pressures, and cannon recoil loads may possibly involve higher frequencies than can be accurately recorded with this method even if strain-gage devices are utilized. Another limitation is the relatively low sensitivity compared to that possible with carrier equipment. In one case, it was necessary to measure a compressive stress of 1000 lbs./in.^{2} in steel to determine the magnitude of a component of a landing load. With two-active gages, the oscillograph record amplitude would be less than 0.1″ if d-c. bridges were used. Carrier equipment having approximately 10 times the sensitivity of the d-c. bridge equipment and providing a flat frequency response up to at least 300 cps. has thus been ordered. This carrier equipment will be designed to accommodate 4-arm strain gage bridges as it is understood that other testing groups have had no drift problems with their carrier equipment when they used strain gages to form the complete bridge.

Since suitable equipment was not available for measuring pressures in hydraulic systems and gun recoil loads when these data were needed, it was necessary to modify the equipment on hand to make these measurements. For hydraulic pressure measurements in flight, the equipment consisted of a tube wound with strain gage wire in combination with the bridge oscillator of a set of 1175-cps. carrier equipment plus a class A amplifier operating a four channel oscillograph with 2600-cps elements. The record was a modulated wave whose amplitude was proportional to pressure. Unfortunately, the drift of this equipment was so great that the hydraulic pressure in the gage had to be continually reduced to zero in order to rebalance before each test. For this reason, the equipment was just barely satisfactory. Laboratory tests indicate that the drift problem is not likely to be as serious, however, with the reluctance type of pressure gages which have recently been developed.

For the cannon recoil tests, strain gages were used with two different types of equipment:

(a) Carrier equipment with a modified output circuit to operate 200-cps. galvanometers.

(b) The standard 3-2000-cps. equipment used for vibration testing in conjunction with the type of strain gage circuit used with the strain-gage accelerometers previously described.

The results with the two sets of equipment agreed with respect to waveshape but not in magnitude. It was suspected that something was wrong with the installation and/or calibration of the strain gages. One interesting point learned from the tests was the fact that the transient characteristics of the 3-2000-cps. equipment did not appreciably affect the shape of the pulse which was of about 70 milliseconds duration.

While the carrier equipment now on order should prove satisfactory for the tests mentioned in the three preceding paragraphs, some possibilities of trouble still exist, namely:

(a) *Oscillator voltage change with time.*—Some cases were observed where the oscillator voltage changed by about 20% as a result of faulty tank circuit components in one case and what was considered to be corrosion from moisture in the other case. Corrosion protection is now a requirement for this reason.

(b) *Microphonics.*—This condition was alleged to be the result of faulty tubes in 3-2000-cps. amplifiers. Since the microphonic frequencies were around 300 cps., these disturbances if present would be reduced by the galvanometer charactertics of the present carrier equipment.

(c) *Hash caused by beat frequencies of different oscillators in the same set of equipment.*—In the one case encountered the hash was eliminated by raising the beat frequency to 400 cps. The path involved in the channel interaction is not definitely known but was present in a strain gage installation.

If the equipment now on order proves to be relatively trouble free, it should satisfy most of the requirements for dynamic test equipment for aircraft. The requirements not only call for accuracy within 5% but specify the following sizes and weights:

(a) 200 in.^{3} and 8 lbs. per channel for the carrier equipment excluding the oscillographs.

(b) 50 in.^{3} and 2 lbs. per channel for the d-c. bridges.

(c) Size and weight of the 34-channel oscillographs to be about the same as the present 12-channel oscillograph (3000 in.^{3} and 70 lbs.)

One further possibility for a reduction in size, which is now being investigated, lies in the development of high-output electromagnetic accelerometers and pressure gages which will directly operate oscillographs through the phase-discriminating detector which has been mentioned previously. To reduce the size of the complete equipment installation, some thought has also been given to the possibility of obviating the need for storage batteries, which have been a nuisance. The carrier equipment will thus receive power from standard 115-v. 400-cps. aircraft inverters which have been found satisfactory for the purpose. Unfortunately, no suitable battery substitute has been found for operating the strain-gage bridges and oscillographs. However, the possibility of a voltage regulator operating from a 24-volt aircraft system is now being considered as an oscillograph power source.

Future developments in dynamic test equipment will center around telemetering for obtaining data for pilotless aircraft and projectiles. Smaller pick-ups (perhaps ½″ diameter by ¼″ high) such as accelerometers and aerodynamic pressure gages will also be required to fit the thin wings which are on the way. Accelerometers approaching this size have already been developed for flutter model tests. Since telemetering systems will probably employ much standard dynamic test equipment and considerable dynamic testing of piloted aircraft is still essential, the equipment described in this article will not be obsolete for some time to come.

A Low-speed Tachometer

By EDWARD C. BLOM, Physics Department, Cornell Aeronautical Laboratory, Buffalo 5, N. Y.

AN electrical indication of the speed of a slowly-rotating shaft may be desired when little power from the shaft is available. At speeds between 1 to 600 rpm, the voltage generated by a conventional tachometer generator is inconveniently low. If gears are used to increase the speed of the tachometer shaft, the power required to drive the tachometer becomes excessive. Another difficulty encountered with brush type generators running at low speeds is caused by a film that develops on the commutator or slip rings after a few hours of running time, and wide fluctuations of the voltmeter reading for the same shaft speed result. These disadvantages are avoided by using a two-phase drag-cup type a-c. motor as the tachometer.

Normally, drag-cup motors are driven by applying two voltages whose relative phase differs by 90 degrees. However, when used as a generator, with an a-c. voltage applied across one of the two windings, the induced a-c. voltage developed across the other winding will be proportional to the speed of the shaft for low speeds. The induced voltage is then amplified to the level desired; since the tachometer output is a.c., a simple, rugged a-c. amplifier is ample for this purpose. After amplification the signal may be made to operate relays, or to move a recording pen as desired.

In Fig. 1, it is seen that winding 2 is connected directly across the source of power, while winding 1 is connected in series with a voltage-dividing network across winding 2. As the shaft of motor M turns, a voltage is induced in winding 1 by winding 2. When an indication of the direction of rotation is not desired, R_2 is set to zero so that no polarizing voltage is present. Fig. 2 shows a typical calibration curve of the tachometer under these conditions. If rotational direction is meaningful, R_2 should be increased to the desired level; now, turning motor M in one direction increases the total output signal while turning in the opposite direction decreases this signal.

When the polarizing voltage has been set to 1.0 volt, there results the curve shown in Fig. 3, which registers both speed and direction. The deviation from linearity of the curve is caused by difference in phase angle between the polarizing voltage and the induced voltage.

The choice of power-supply voltage is determined by the maximum amount of dynamic braking that the mechanical system can tolerate. Decreasing the supply voltage reduces the amount of braking, but in so doing increases the tachometer sensitivity to external electrical disturbances. Fifty volts was found to be a good compromise. Under these conditions the torque required to rotate the shaft is 0.0005 ounce-inches.

Since the level of output signal depends directly upon the value of the power supply voltage, accuracy greater than the limits of power supply regulation should not be expected.

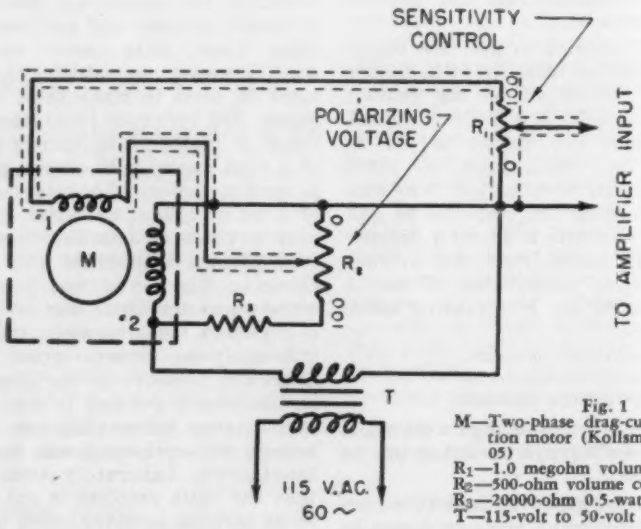


Fig. 1
M—Two-phase drag-cup type induction motor (Kollsman Type (799-05)
R_1—1.0 megohm volume control
R_2—500-ohm volume control
R_3—20000-ohm 0.5-watt resistor
T—115-volt to 50-volt transformer

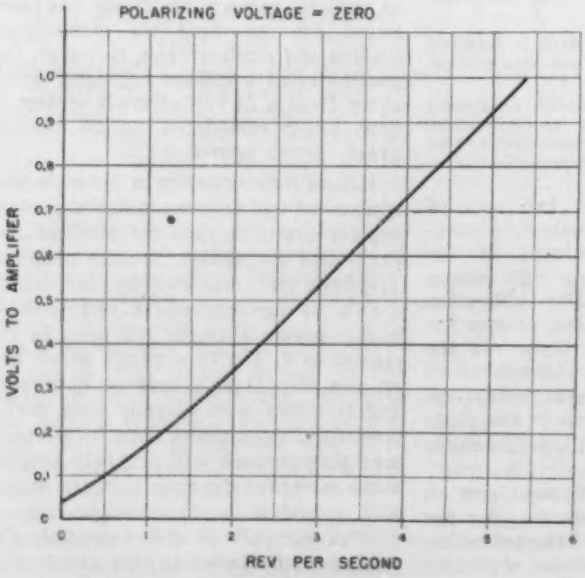


Fig. 2. Calibration curve $d\phi/dt$ recorder.

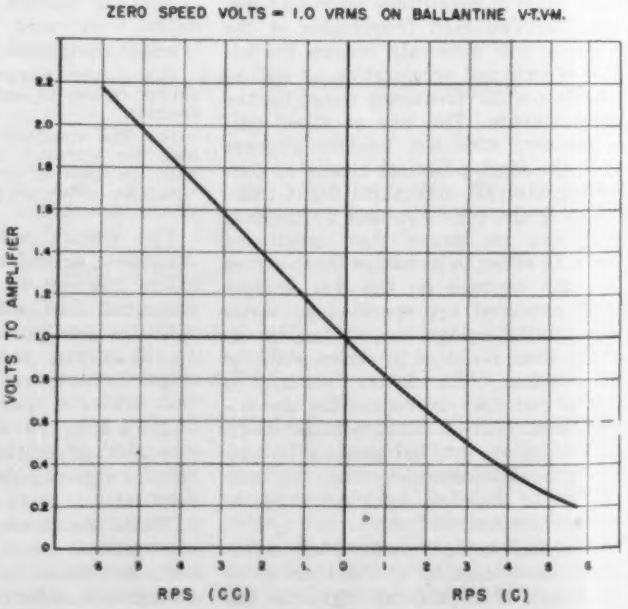


Fig. 3. Calibration curve $d\phi/dt$ recorder.

Sound and Vibration Measurements*

By H. A. LEEDY, Armour Research Foundation, Chicago

Introduction

THE subject of the control of sound and vibration is of extreme importance to industry today. Unwanted sound or excessive vibration is generally associated with poor workmanship or poor mechanical design. Excessive office or factory noise often results in lowered efficiency. The consumer is becoming increasingly conscious of noise and vibration, and is more critical about these disturbances than ever before. It behooves all of us to learn more about methods of controlling these undesirable and frequently unnecessary disturbances.

In the control and reduction of these undesirable sounds and vibrations, one of the first steps is to be able to measure them. However, before discussing measurements, it is important to know more about what we want to measure.

Since sound, in the physical sense, is a vibratory motion, the measurement of vibrations includes the measurement of sound. The dictionary defines sound as those vibrations which affect the sense of hearing. However, just as it is becoming customary to regard light as including invisible radiation in the infrared and ultraviolet, so it has become common practice to include as sound those vibrations which are inaudible—infrasonic and ultrasonic. For example, during the war a large research program was carried on in a field called "Underwater Sound," although most of this work was in the ultrasonic region outside the range of hearing.

*Presented at the first Annual Conference of the Instrument Society of America, William Penn Hotel, Pittsburgh, Penna., Sept. 16-20, 1946.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

However, for purposes of the discussion which follows, we will use the more limited definition of sound and include only those frequencies in the audio range, namely 20 to 20,000 cps. Later, in discussing vibration measurements, we will confine our attention to those vibrations most troublesome in industrial machinery. These mechanical vibrations are of low frequency, ranging from a few cycles to a few hundred cycles per second.

Sound Measurements

In any discussion of sound measurements it must be clearly understood that there are two aspects to the word "sound": (1) the subjective or psychological aspect and (2) the objective or physical aspect. Subjectively, sound is the sense impression of the organ of hearing; objectively, it is the actual vibratory motion which produces this sensation.

In all sound measurements it must be borne in mind that it is the physical properties which are measured, not the sensation properties. The physical properties of principal interest, are: (1) the intensity, measured in watts per square centimeter per second, or the corresponding logarithmic unit, intensity level, measured in decibels, and (2) the frequency, measured in cycles per second. In a complex sound consisting of many frequencies, it is necessary to measure the intensity level at each frequency or, in other words, to determine the frequency spectrum.

All of us are familiar in a qualitative way with the subjective characteristics of sound. There are three principal characteristics which we can readily distinguish: loudness, pitch and quality. It is the ultimate goal of practically all sound measurements to be able to interpret physical measurements in the terms of the subjective sensation which the ear perceives. Casual observation would indicate that this interpretation is quite simple, the pitch being determined only by frequency, and loudness only by intensity level. However, careful measurements have shown that the relationship between the subjective properties and the physical properties is very complex. Such measurements have shown that although pitch is primarily determined by frequency, it is also dependent to some extent upon intensity level. This variation of pitch with intensity level can readily be observed by suddenly changing the volume control on an oscillator tone.

The dependence of loudness upon frequency and intensity level is much more complex. This relationship can best be shown graphically as illustrated in Fig. 1. In this graph, the curved lines are contours of equal loudness. It is observed that at the low and high frequencies the intensity level must be considerably greater than in the mid-frequency range to produce the same sensation of loudness. For example, a thousand-cycle note having an intensity level of 20 decibels is as loud as a 50-cycle note having the considerably higher intensity level of 63 db.

With the above information as a background, we are now in a better position to discuss the measurement of the physical properties of sound and their relationship to our subjective sensations. The measurement of the physical properties of sound, even under the best conditions, is a difficult problem. It has been stated by Morse: "In no other branch of physics are the fundamental measurements so hard to perform and the theory relatively so simple; and in few other branches are the experimental methods so dependent

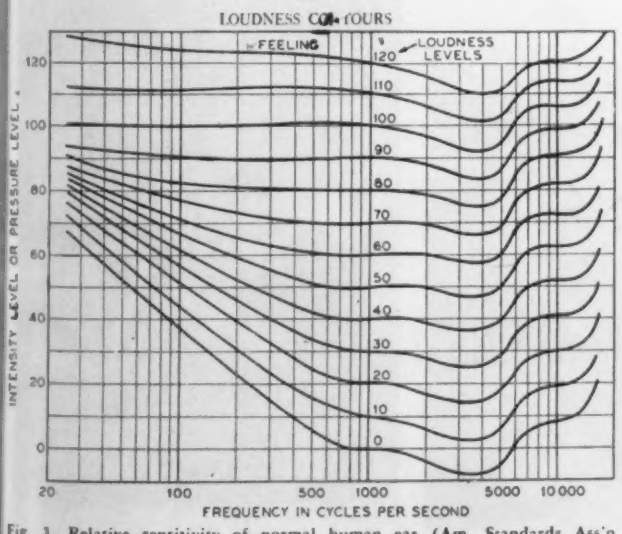


Fig. 1. Relative sensitivity of normal human ear (Am. Standards Ass'n results) to low-, medium- and high-pitched pure tones.

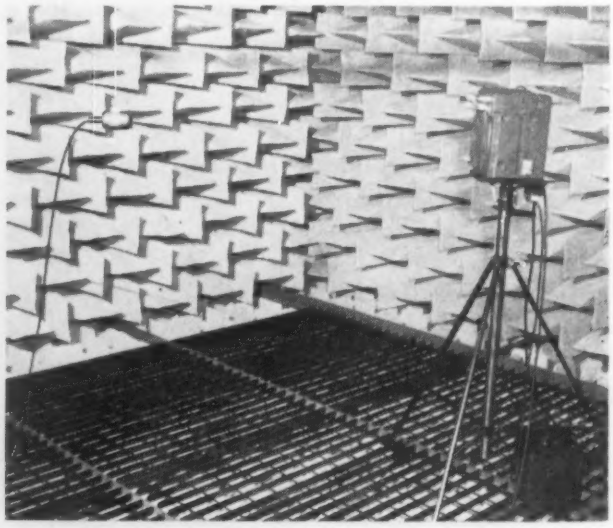


Fig. 2. Free Field Room for Sound Measurements.

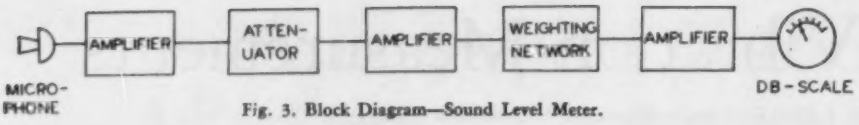


Fig. 3. Block Diagram—Sound Level Meter.

upon a thorough knowledge of the theory."

One of the reasons for this difficulty is the infinitesimal magnitude of the energy in a sound wave. If, for example, all of the people in the city of Pittsburgh were to begin talking in a normal conversational tone, and if it were possible to collect the entire sound output of this large group and convert it without loss into electric energy, there would barely be enough power to light a 10-watt electric lamp. Obviously, the sensitivity of acoustical instruments must be very high.

The large intensity ranges encountered in sound measurements present still another difficulty. Intensities differing by a factor of 10^{13} (ten billion

Fig. 4. Sound Level Meter.

	DECIBELS		INTENSITY UNITS	SOUND PRESSURE DYNES/SQ.CM.
	120	THRESHOLD OF FEELING	1,000,000,000,000	200.
VERY LOUD DEAFENING	110	THUNDER, ARTILLERY NEARBY RIVETER ELEVATED TRAIN	100,000,000,000	
	100	BOILER FACTORY	10,000,000,000	20.
	90	LOUD STREET NOISE NOISY FACTORY TRUCK UNMUFFLED POLICE WHISTLE	1,000,000,000	
	80		100,000,000	2.
LOUD	70	NOISY OFFICE AVERAGE STREET NOISE AVERAGE RADIO AVERAGE FACTORY	10,000,000	
	60		1,000,000	0.2
MODERATE	50	NOISY HOME AVERAGE OFFICE AVERAGE CONVERSATION	100,000	
	40	QUIET RADIO	10,000	0.02
FAINT	30	QUIET HOME OR PRIVATE OFFICE AVERAGE AUDITORIUM QUIET CONVERSATION	1,000	
	20		100	0.002
VERY FAINT	10	RUSTLE OF LEAVES WHISPER SOUND PROOF ROOM	10	
	0	THRESHOLD OF AUDIBILITY	1	0.0002

Fig. 5. Summary of Sound Measurements for Some More Common Sounds.

Fig. 6. Automatic Frequency Analyzer.

billion) can be detected by the ear and it is desirable to design sound instruments capable of measuring this extremely wide range.

Perhaps one of the greatest difficulties encountered in sound measurements is the interference resulting from reflection and refraction. If one attempts to measure the output of a loudspeaker in an ordinary room, he will experience no end of difficulty because of the standing wave pattern resulting from reflections from the walls. Under such conditions the intensity measured at a point at some distance from the loudspeaker may be several times greater than the intensity measured at some point nearer the loudspeaker. One method of avoiding such reflections is to make such measurements outdoors. Difficulties still persist here because of refraction of sound due to wind or temperature gradients.

In order to avoid these difficulties, special rooms have been designed with highly absorbent walls to minimize effects of reflection. A photograph of such a room is shown in Fig. 2. In this room the walls are covered with wedges of glass wool with the result that less than 0.01% of the incident sound energy is reflected. Such a room approximates the outdoors without having the disadvantages of inclement weather, wind and temperature gradients.

Because of these difficulties, especially that of the minute energy contained in a sound wave, early experimenters had an almost impossible task

Fig. 7. Apparatus for Automatic Measurement of Frequency Response.

in trying to measure sound intensities. A very ingenious method of measuring sound intensity was devised by Lord Raleigh. It consisted of a thin disk suspended by a quartz filament. Sound waves incident on this disk caused it to rotate; from the angle of rotation the intensity could be calculated. The Raleigh disk has relatively poor sensitivity and is difficult to use. However, it is one of the few instruments whose calibration is absolute and even today is used for the calibration of "standard" microphones.

However, in spite of the ingenuity of early experimenters, there was little progress in the measurement of sound until the vacuum tube came to the rescue. With the development of high-gain electronic amplifiers, the science of sound measurement grew by leaps and bounds. This resulted in a renewed interest in the subject of sound and its measurement. Practically all sound measuring instruments today are, in part, electronic.

One of the most widely used instruments for sound measurement is the so-called sound level meter. In this instrument an attempt is made to adjust the frequency response so that the reading corresponds to loudness level rather than intensity level. The information contained in Fig. 1 is of considerable value in the design of such instruments. In present-day sound level meters, the frequency response of the electronic amplifier is altered by "weighting networks" (filters) so that the response approximates that of the ear. It is evident from Fig. 1 that in order to accomplish this exactly, the weighting network must change continuously as the intensity changes. Actually, in present commercial instruments only three different weighting networks are used, each one being a compromise for a specified range of intensities.

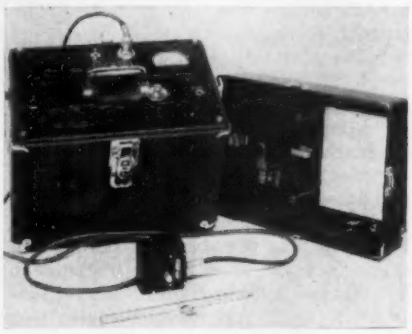


Fig. 10. Vibration Meter.

A block diagram of such a sound level meter is shown in Fig. 3. In addition to the weighting network, an attenuator is inserted in the circuit in order to be able to accommodate the wide range of intensities. It is evident that before the advent of electronic amplifiers, the development of such an instrument would have been practically impossible.

In Fig. 4 is shown a commercial model of a widely-used sound level meter. This instrument is capable of measuring intensity levels from 25 to 130 db and has three weighting networks; one for low-intensity sounds, a second for moderate-intensity sounds, and a third for high-intensity sounds. This meter is operable from either a battery for portable field use or from a power pack for laboratory use. With instruments of this general type the intensity levels of many different sound sources have been measured. A summary of such measurements for some of the more common sounds is given in Fig. 5.

The sound level meter gives an indication of the overall intensity level of both pure tones and complex sounds. For pure tones (sine waves) the only additional information required is the frequency. However, for complex sounds, as has been indicated earlier, it is desirable to know the intensity level at all frequencies, i.e. the frequency spectrum.

In Fig. 6 is shown a set of equipment suitable for obtaining automatically the frequency spectrum of a given sound. This equipment consists of a sound level meter, a motor-driven frequency analyzer, a logarithmic amplifier, and a pen and ink recorder. With such equipment it is possible to obtain a graph in which the intensity level in decibels is plotted against frequency. The principal advantage of such equipment is that the frequency spectrum can be obtained much more rapidly than by other methods in which similar information has to be obtained by plotting the curve point by point.

A common type of sound measurement is the determination of the frequency response of microphones, loudspeakers and sound-recording and -reproducing equipment. In Fig. 7 is shown a set of instruments for making such response measurements automatically. It consists of an oscillator for producing a tone of any frequency in the audio range plus an intensity level recorder which is coupled to the oscillator. With such equipment, frequency response curves on most types of acoustical equipment can be made rapidly.

The acoustical properties of rooms, auditoriums, radio studios, etc., are best determined by measurement of the rate at which sound decays in the enclosure. This rate of decay is often quite rapid and it is necessary to have intensity level equipment suitable for measuring this rapid rate of decay. A suitable instrument for this purpose, called a high-speed level recorder, is shown in Fig. 8. It is capable of following changes in intensity level as rapid as 300 db/sec.

In sound measurements it often occurs that the sound we wish to analyze is of relatively short duration and may occur only once. Such sounds can be analyzed by first making a recording of the sound which can then be played over and over again for detailed study

Fig. 8. High Speed Level Recorder.

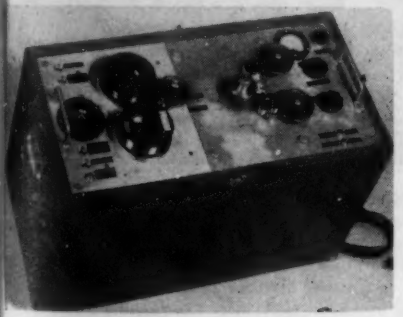


Fig. 9. Magnetic Wire Recorder.

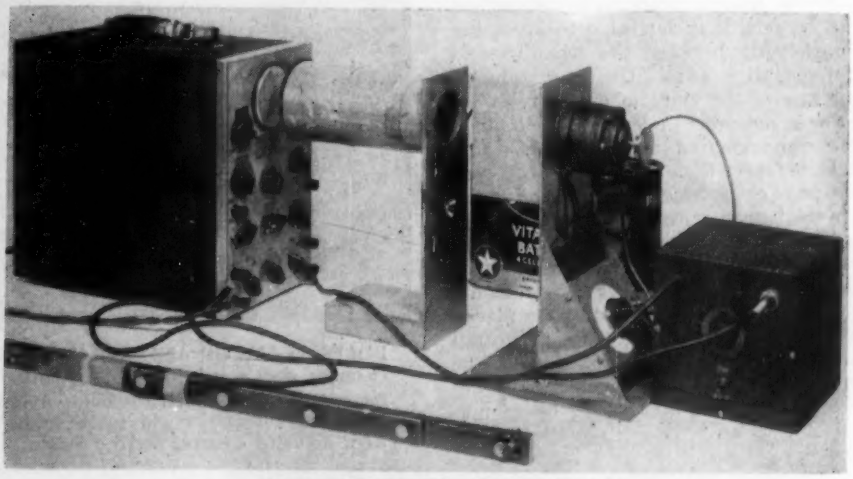


Fig. 11. Transient Vibration Recorder.

and analysis. The Armour Research Foundation has developed a magnetic wire recorder which has proved very useful for such studies. This recorder is shown in Fig. 9. Its frequency response is flat within ± 1.5 db from 30 to 15,000 cps. and it is capable of making continuous recordings over a half-hour period.

This recorder has also proved very valuable as an "acoustical notebook." For example, in noise-reduction research on industrial machinery, it is often desirable to make sound recordings of the noise with each change in design. Such recordings can then be played back later, when the loudness as well as the quality of the noise from the several designs can be compared.

Vibration Measurements

Although the lower limit of hearing for average individuals is about 20 cps., frequencies lower than this can cause considerable annoyance. Such vibrations can be felt rather than heard. This ability to feel vibrations through the sense of touch extends well up into the audible range. Instruments to measure such vibrations must necessarily have a lower frequency response than sound measuring instruments.

In vibration measurements several magnitudes can be measured: (1) frequency, (2) displacement, (3) velocity and (4) acceleration. As in sound, the magnitudes which one chooses to measure depend upon the information required for the particular problem.

For example, a determination of the frequency of a given vibration often points to the source of the vibration, such as an unbalanced wheel or gear rotating at the same frequency. Also, in the design of vibration isolation supports, a knowledge of the frequency of the vibration to be isolated is required. In rotating or reciprocating machinery, vibrations often produce stresses which, if excessive, will result in the failure of the vibrating member. In this case, the amplitude of the vibration is measured in order that these stresses may be calculated. Vibration acceleration measurements are often made in automobiles and other vehicles to determine the magnitude of the bumps or jerks which the passengers experience.

Since many mechanical vibrations can be felt, it is desirable to know the relationship between the stimulus and the sensation effect. Unfortunately, in the case of the vibrations, this relationship is not well understood and much research remains to be done in this field before we can determine the sensation effect from a measurement of the physical properties of vibration.

Early instruments for measuring vibration amplitude were generally of the "seismic" type. These instruments were large and bulky and, when placed in contact with the vibrating part, often materially alter the amplitude of the vibration. Here again, electronic developments have proved to be of material aid by providing smaller, more sensitive instruments.

A very useful electronic vibration instrument is shown in Fig. 10. It consists of a piezoelectric vibration pick-up, an electronic amplifier and a calibrated output meter. The pick-up consists of a small square crystal rigidly mounted at three corners, the fourth corner being free to vibrate. The natural frequency of this crystal is such that for vibration frequencies below 1,000 cps. the voltage output of this pick-up is proportional to the vibration acceleration. By suitable electrical integrating networks, it is possible also to measure velocity and amplitude. This instrument indicates acceleration in inches per second per second, velocity in microinches per second or amplitude in microinches. Thus in one instrument is contained a "vibrometer," a "velocitometer" and an "accelerometer"—a combination impossible with previous mechanical types of instruments.

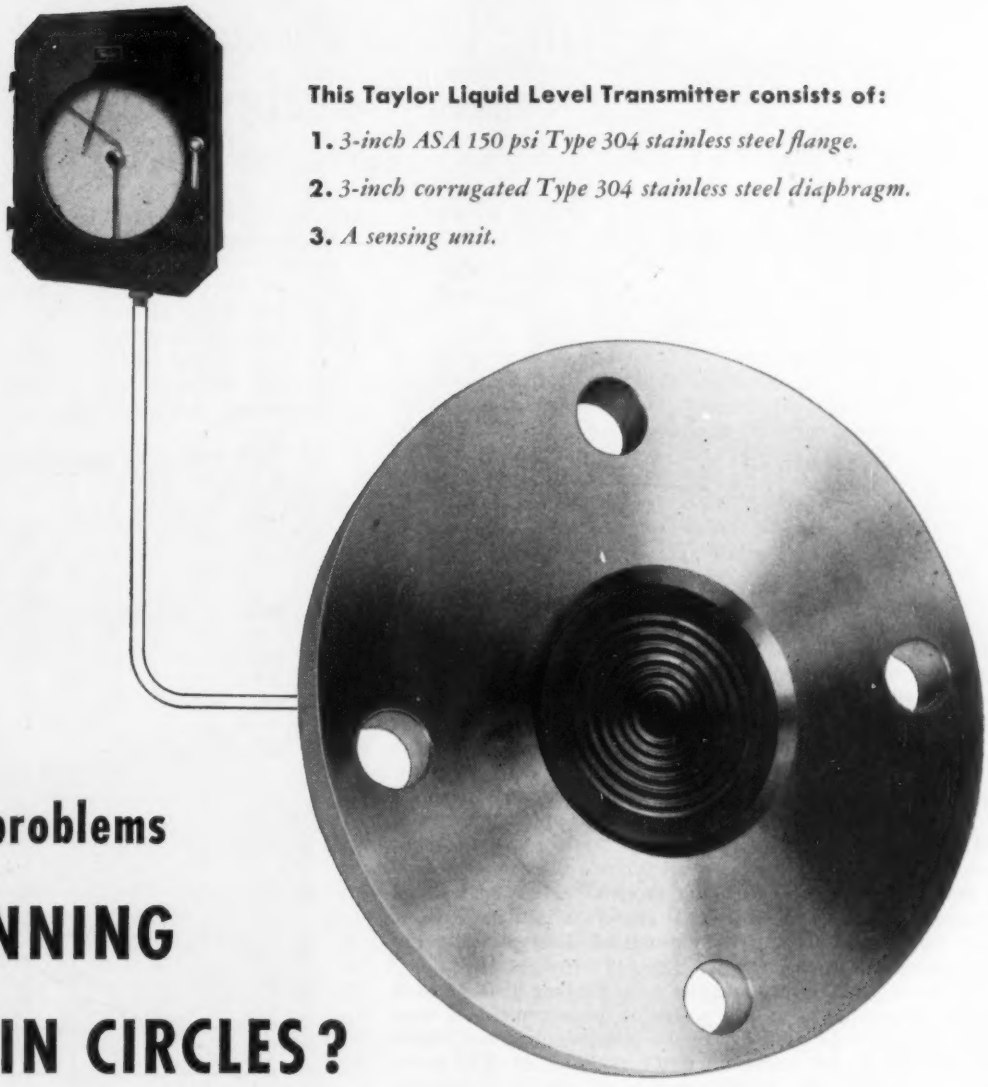
For many types of vibration measurements in which large accelerations are involved, the crystal pick-up is too fragile. In this case, a resistance pick-up (often called a strain gage) or a dynamic pick-up is preferable.

A vibration engineer is often required to measure the wave-form of transient vibrations. In this case the indicating instrument must have a very rapid response, such as one can obtain with a string oscillograph or a cathode-ray oscillograph. In Fig. 11 is shown a set of equipment suitable for the measurement of transient vibrations. In this particular equipment the output from a resistance type pick-up is amplified and then sent to the deflecting plates of a cathode-ray tube. The motion of the light spot on the cathode-ray screen is photographed by a special camera containing a continuously-moving film. In this way a permanent record of the wave-form of the transient vibration is obtained.

Many other types of vibration-measuring instruments are available for use to the vibration engineer. Although there is no universal instrument for measuring all types of vibrations, a good engineer thoroughly familiar with the theory of vibrations can usually find a suitable instrument to meet his special needs.

INSTRUMENTS ON THE MARCH

POLES, EQUATOR AND STRATOSPHERE: Into the controlled-conditions test chamber goes a radar instrument built for the U. S. Navy. When the door is closed, engineers can change the "climate" to sub-zero temperatures or, by saturating the interior with steam, to the hot humid tropical atmosphere. In addition, pressure controls make possible the testing of aircraft instruments under varied atmospheric conditions of altitudes up to 80,000 feet. *(Industrial Electronics Division of Westinghouse Electric Corp.)*



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MEAN

ACCURACY FIRST

IN HOME AND INDUSTRY

Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

XII. GAS ADSORPTION APPARATUS FOR MEASURING SURFACE AREAS

[This article was prepared in collaboration with Dr. Leslie G. Joyner, Mellon Institute of Industrial Research]

In recent years the study of the adsorption of gases on solids has received considerable attention from both the theoretical and applied scientist. This is due in a great part to the excellent work of Brunauer, Emmett and Teller[1]. They showed how the total area of a porous or finely divided powder could be calculated from gas adsorption data. Because of the increasing importance of this type of work, this article will be devoted to a description of the most general form of gas adsorption apparatus. Details of the operation and method of obtaining the surface area will be included.

The surface area of a solid is of extreme importance in many chemical processes where gas or liquid reactions occur either on the surface or under the influence of the surface of solids. Contact catalytic reactions, such as take place in the cracking of hydrocarbons, the hydrogenation of vegetable oils and adsorption refining processes such as occur in clay treating of gasolines and in sugar refining are a few cases where surface area is important. Since most of the solids which are used as catalysts or adsorbents in this type of work are of a porous nature an adequate measure of the surface area must include the area involved in the walls of the pores (the internal area) as well as the external area. Indeed in most cases the internal area is many times greater than the external and is generally the more important of the two.

The problem in measuring the total surface area of such porous substances is to find a unit of measurement of area small enough to be used in the sub-microscopic pores which may be only a few angstrom units in diameter. The molecules of a gas such as nitrogen prove to be a suitable yardstick and have the advantage that we know or can estimate their size with a reasonable degree of accuracy. If one could completely cover the surface of a solid including the internal area with a single layer of gas molecules (e.g. nitrogen) and then count the number of molecules it took to do so it would be possible to determine the total area since the area covered by a single molecule can be determined from known physical constants of the gas. This is essentially the procedure developed by Brunauer, Emmett and Teller[1] who will hereafter be referred to as BET. They showed how to count the number of molecules of a gas corresponding to a single layer covering the entire surface of a solid.

When a solid is exposed to a gas a definite amount of the gas will adhere to or be adsorbed on the surface of the solid if the temperature is in the neighborhood of the normal boiling point of the gas. This adsorption is due to forces similar to those which are involved in the condensation from the gaseous to the liquid state. The volume of gas which will be adsorbed on any given surface depends upon both the temperature and the pressure of the gas. As the temperature is increased, the amount of gas adsorbed decreases. On the other hand the effect of an increase in pressure is to increase the adsorption. In the determination of the area the temperature is kept constant and the amount of gas adsorbed is measured as the pressure is altered. A plot of such data is called an adsorption isotherm. Although the study of adsorption phenomena in general is extremely important, for the purpose of this article we will consider only the adsorption of nitrogen at temperatures close to its normal boiling point (—195.8°C.) since this is the gas most generally used for area measurement. A typical nitrogen isotherm is shown in Fig. 155.

Adsorption isotherms have been classified into five general types but the "S" shaped isotherm shown in Fig. 155 is by far the most common type and the one to which the BET theory in its simplest form applies. (For a more detailed study of the types of isotherms one may consult "The Adsorption of Gases and Vapors, Vol. I, Chapter VI by S. Brunauer). Although many attempts to explain adsorption phenomena have been made, it was not until BET developed the so-called "multilayer theory" that a satisfactory explanation of all five types of adsorption isotherms was possible. The basic assumption of the BET theory is that several layers of gas can be adsorbed on a solid surface. The BET theory results in the following expression for the isotherm of a gas adsorbed on a free surface.

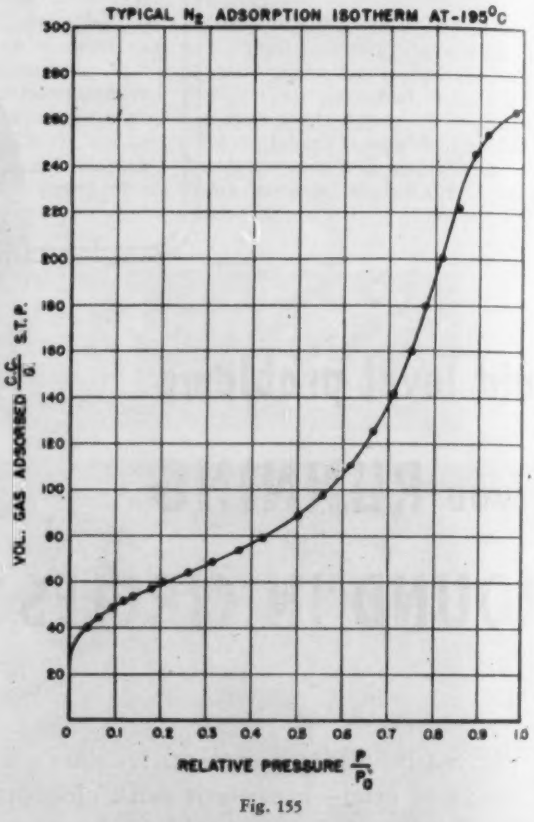


Fig. 155

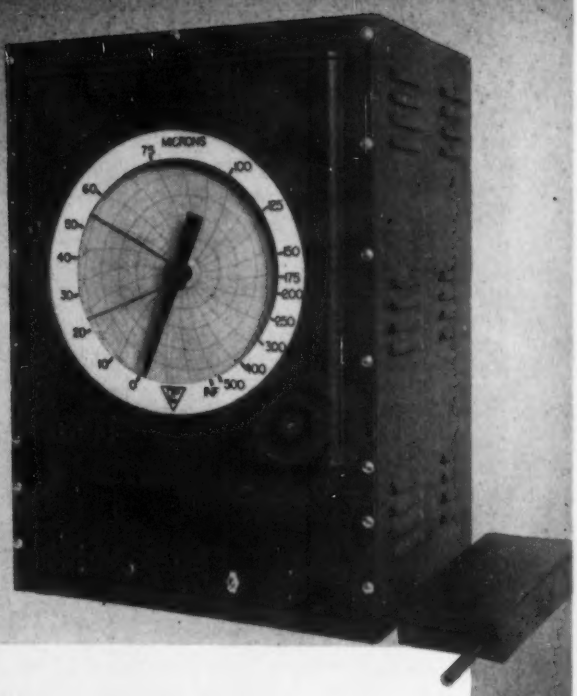
$$V = \frac{V_m cP}{(P_0 - P)\,(1+(c-1)\,P/P_0)} \qquad (28)$$

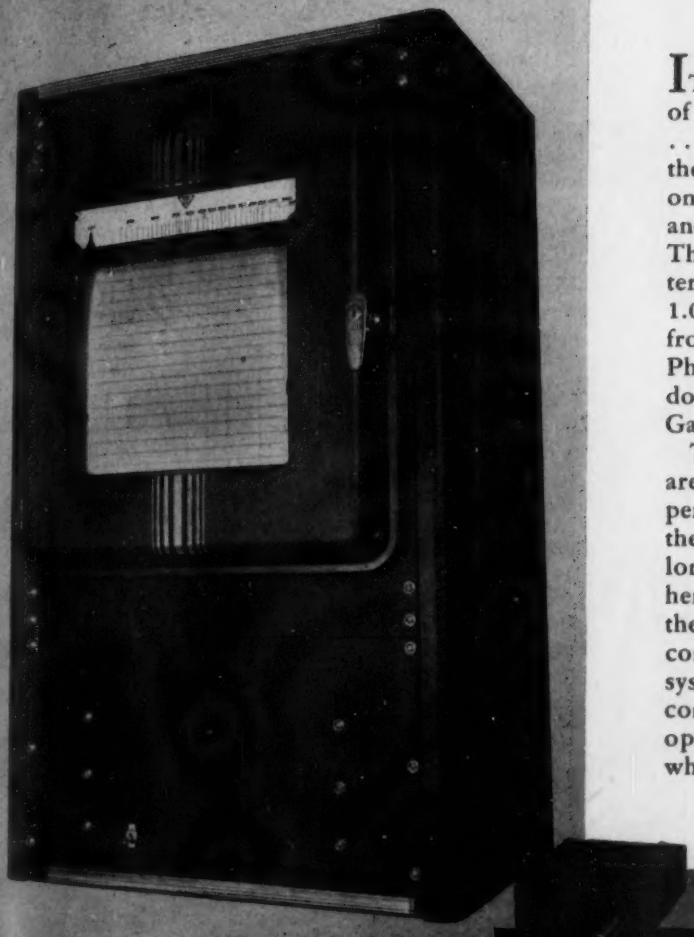
where V is the volume of gas at 0°C. and 1 atmosphere pressure, P is the pressure, P_0 is the vapor pressure of the gas at the temperature of the adsorbent, c is a constant related to the heat of adsorption and V_m is the volume of gas (s.t.p.) necessary to form a single layer over the entire surface. It is the determination of the constant V_m which makes possible the measurement of the total area.

Although equation (28) was derived for a flat surface it is still applicable over a limited range to porous materials which have typical "C" shaped isotherms. For certain extreme types of "S" shaped isotherms a more complicated form of equation (28) becomes necessary[2].

Of the various quantities in equation (28) P, P_0 and V

HIGH-VACUUM RECORDS *At a glance*





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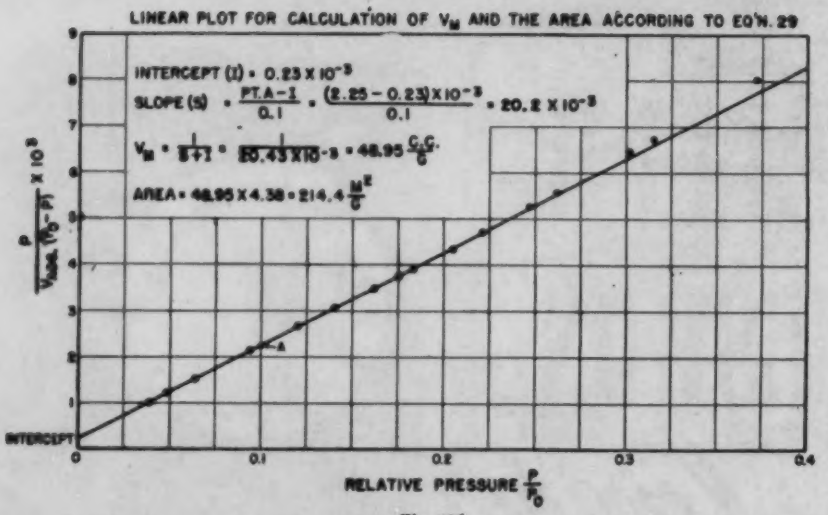
LINEAR PLOT FOR CALCULATION OF V_M AND THE AREA ACCORDING TO EQ'N. 29
INTERCEPT (I) = 0.23 X 10⁻³
SLOPE (S) = (PT.A−I)/0.1 = (2.25 − 0.23) X 10⁻³/0.1 = 20.2 X 10⁻³
V_M = 1/(S+I) = 1/20.43X10⁻³ = 48.95 cc/c
AREA = 48.95 X 4.36 = 214.4 M²/c
INTERCEPT
RELATIVE PRESSURE P/P₀

Fig. 156

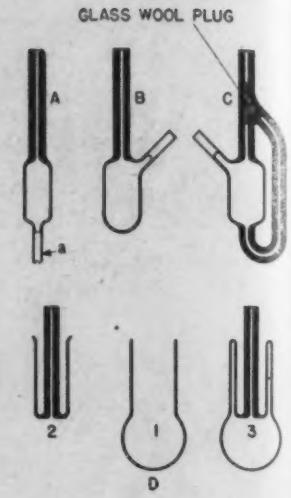

Fig. 158

are determined experimentally and V_m and c can be obtained by putting equation (28) into linear form

$$\frac{P}{V(P_0-P)}=\frac{1}{V_m c}+\frac{c-1}{V_m c}P/P_0 \qquad (29)$$

and plotting $P/[V(P_0-P)]$ vs P/P_0. If equation (28) is valid such a plot should give a straight line with

$$\text{slope } (s)=\frac{c-1}{V_m c} \text{ and intercept (I)}=\frac{1}{V_m c} \qquad (30)$$

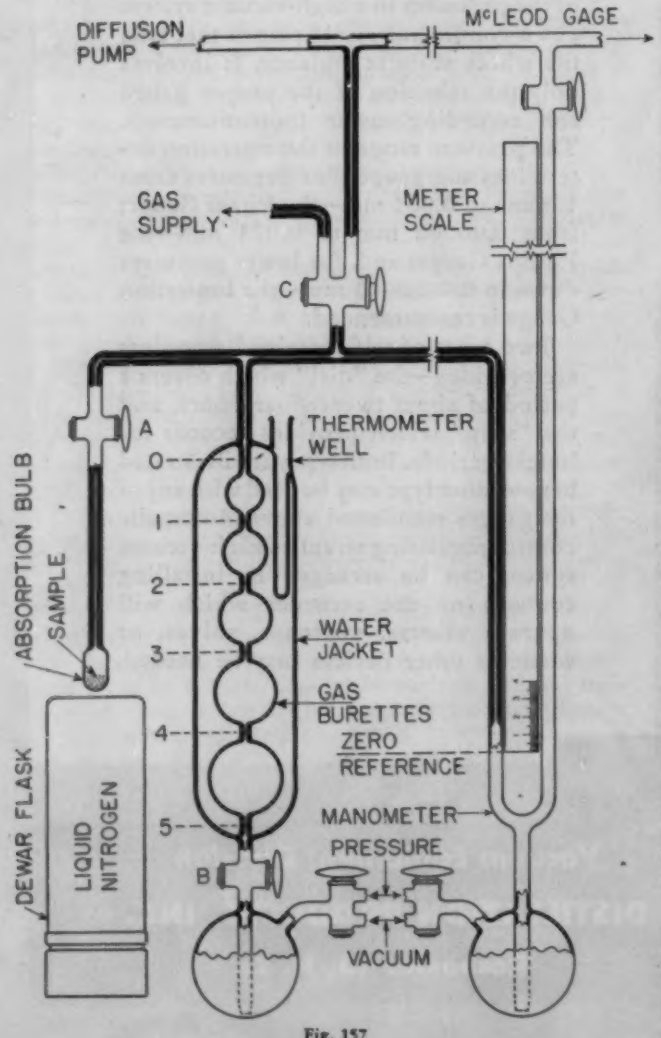

Fig. 157

For most isotherms a straight line is obtained for only the lower portion of the isotherm up to a relative pressure (P/P_0) of about 0.3. This straight line, however, is sufficient to determine the constants V_m and c from its slope and intercept. From equations (30) it is easy to show that

$$V_m=\frac{1}{s+I} \text{ and } c=\frac{s}{I}+1 \qquad (31)$$

Fig. 156 shows the isotherm of Fig. 155 plotted according to equation (29).

Since V_m is the volume of gas at 0°C. and one atmosphere necessary to cover the surface with one layer of gas it is a simple matter to convert it to the number of molecules involved. A detailed discussion of the various assumptions involved in the determination of the area covered by each molecule is not in place here. Such a discussion is given by BET[1]. The end result shows that the total surface area is related to V_m as follows:

$$\text{Area (sq. meters)} = 4.38\ V_m \text{ (cc.s.t.p.)} \qquad (32)$$

Description of the Apparatus

Having developed a brief outline of the theory it is now necessary to consider an apparatus which will give the experimental data necessary to determine the surface area of a porous or finely divided solid. The type of apparatus discussed here is not the only kind which will give suitable data but it is one of the most common types. The essential parts of the apparatus and its manipulation will be described first. In addition it will be helpful to describe some auxiliary apparatus that may be incorporated into the system in order either to increase the precision and accuracy of the data or to increase the ease of manipulation.

First, however, it will be helpful to consider what is expected of the apparatus. In order to determine the area utilizing the BET theory, we must have the data necessary to make a plot similar to Fig. 156 in which $P/[V(P_0-P)]$ is plotted against P/P_0. Consequently the quantities needed to determine a particular point are P the pressure, V the volume of gas adsorbed at the pressure P, and P_0 the vapor pressure of the gas at the temperature at which the adsorption is being determined. Since several points are required the apparatus should be capable of altering the pressure so that a series of points can be determined without too much difficulty. Inasmuch as P_0 will depend solely upon the temperature of the low temperature bath, it can be determined independently of the actual adsorption data, i.e. P and V.

The common form of low-temperature adsorption apparatus shown in Fig. 157 meets all the requirements outlined above. The volumes of the various bulbs in the burette are determined before the apparatus is assembled. The remaining volume of the system between the zero of the manometer and the stopcock A is calibrated as will be described

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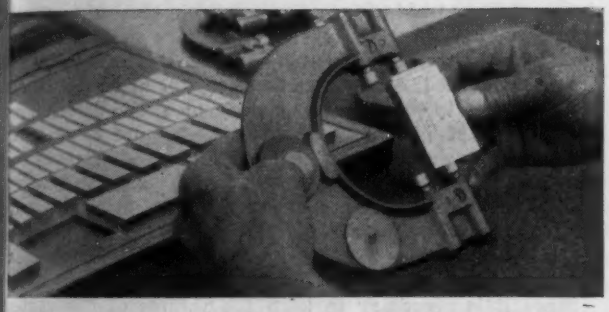

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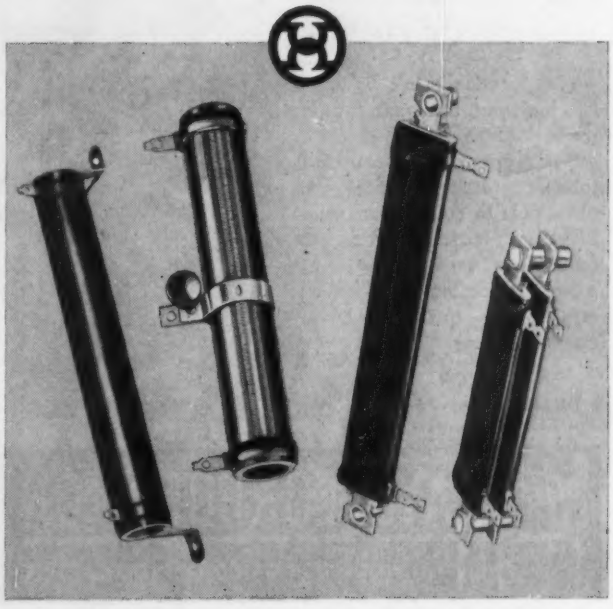

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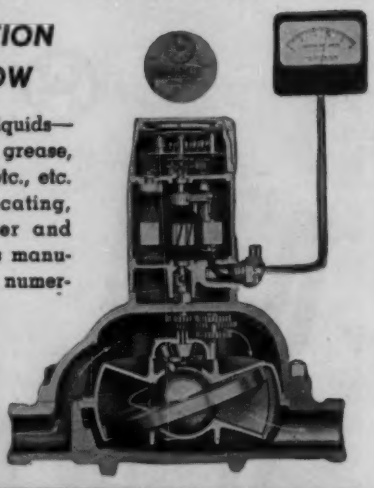

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later. The volume of the free space in the adsorption bulb is determined by calibration with helium at the temperature of liquid nitrogen. Helium is used because its adsorption at liquid nitrogen temperature is effectively zero on nearly all solids. Once the volume of all parts of the apparatus is known and the system evacuated, a sample of nitrogen can be admitted to the burette with stopcock *A* closed. By determining the pressure and the temperature of the burette this volume can be converted to standard conditions. With the liquid nitrogen bath surrounding the adsorption bulb, stopcock *A* is then opened. After allowing sufficient time for equilibrium to be established, the pressure is again determined. This, together with the known volume of the system up to stopcock *A*, allows the determination of the volume of gas remaining in the burette. The calibration of the adsorption bulb permits one to calculate the amount of gas in the adsorption bulb. Thus the volume of gas adsorbed is the original volume taken minus the amount remaining in the burette and the amount in the adsorption bulb. By allowing the mercury to fill the various bulbs of the burette the volume of the system can be altered by known amounts and hence several points can be taken in succession without any difficulty.

As indicated in Fig. 157, some auxiliary apparatus is required such as the high vacuum system, gas reservoirs, etc. Since vacuum pumps and gages have previously been discussed, they will not be mentioned except to point out that they are needed. The details on the rest of the system will now be discussed.

Gas Reservoirs

Two gas reservoirs of 2- to 5-liter capacity are required, one for the helium to be used in the calibrations and one for the adsorbate which we will assume to be nitrogen. They should be attached to the system in such a way that they can be completely evacuated before being filled with the gas. It is good practice to keep the pressure in the reservoirs always above atmospheric so that there will be no danger of air leaking into the reservoir through a faulty stopcock. Care must be taken not to have the pressure so high that the stopcocks are blown loose. Pressure stopcocks are recommended. An open end manometer at least 76.0 cm. long attached to the reservoir is convenient for determining the amount of gas in the reservoir. A more complicated type of reservoir but one which has certain advantages and can be used for storing gas at subatmospheric pressures will be described later in connection with a more elaborate apparatus.

Manometer

Since it is necessary to keep the volume of the system constant, the mercury in the pressure leg of the manometer is always adjusted to a reference point corresponding to the zero point of the scale. The manometer should be made of 10-mm. tubing so as to minimize meniscus effects of the mercury. In order to avoid capillary effects the manometer at the reference point must have the same diameter as the opposite leg. The reference point should, however, be as close to the capillary tubing as possible and still have the proper diameter, otherwise the free space of the system will be needlessly increased. The manometer should also extend for several inches below the reference point so as to avoid the danger of the mercury being accidentally forced around the "U" bent during a rapid increase in pressure.

Burette

The burette, Fig. 157, consists of a series of bulbs of various sizes connected by short lengths of capillary tubing. Some type of reference mark is made on each capillary tube and also below the bottom bulb and above the top bulb. In this way each bulb has a reference mark above and below it and the volume between the marks for each bulb must be accurately known. These volumes are determined by calibrating with water or mercury before the burette is attached to the system. In order to calibrate the burette the stopcock *B* should be attached. By means of a vacuum pump

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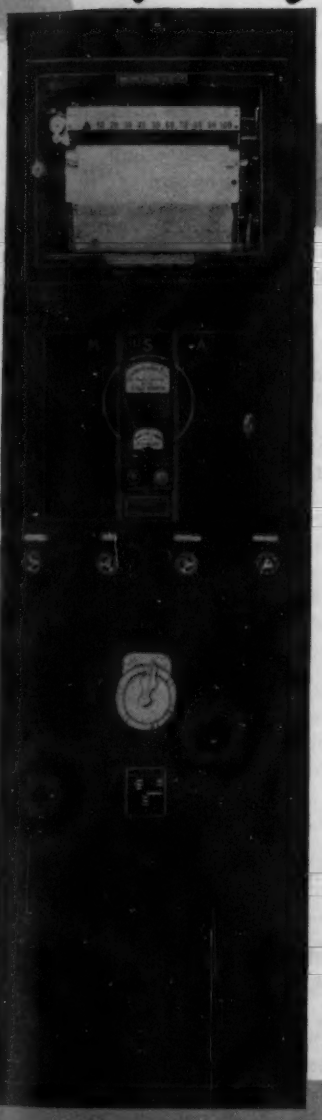

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attached to the upper capillary, mercury may be drawn up into the burette filling all the bulbs up to the top reference point. The flow of mercury is, of course, controlled by the stopcock. The temperature of the burette is then taken. A tared beaker is placed under the stopcock which is then opened until the mercury drops to the second reference mark. The volume of mercury collected in the beaker will correspond to the volume of the top bulb. The mercury collected is then weighed and from the density of mercury at the temperature of measurement, the volume of the bulb corrected to 0°C. will then be

$$\text{Vol. (cc.)} = \text{weight (gm)}/d \text{ (gm/cc.)}.$$

Since most of the gas volume in the system is in the burette bulbs, it is important that the burette be thermostated. This may be accomplished simply by a water jacket with an air jet for agitation or liquid from a constant temperature bath may be circulated through the jacket. In either case the temperature should be known accurately to at least 0.1°C.

The size of the various bulbs of the burette is not too important. A convenient range of volumes is 5, 15, 25, 50, 130 cc. If the volumes are too large the pressure increments will be large and the various readings may be too far apart for accuracy. On the other hand small burette volumes make it difficult to cover a reasonable range of pressures.

Adsorption Bulb

This is the container which holds the sample of adsorbent. There is no set design for such a bulb and the type used may vary according to the nature of the adsorbent. The principal requirements are low free space, i.e. no larger than necessary to hold the sample, and ease of construction. Several types are shown in Fig. 158. The simplest and the most convenient bulbs for most ordinary adsorbents are shown in Fig. 158, A and B. The adsorbent is introduced through the tube "a" which is then sealed off. The container, Fig. 158, C, is useful when the adsorbent is very finely divided. The two outlets decrease the rate of flow of gas and the glass fiber plugs stop the adsorbent from being blown out of the bulb during the degassing process. This is an important advantage for materials such as "fluid" cracking catalysts. The bulb, Fig. 158, D, is used when the adsorbent is of such a nature that it cannot be heated. The bulb is made in two parts, 1 and 2. The sample is placed in the bottom of 1. The bulb, 2, is then placed inside of 1 and the final seal made around the upper rim at 3. This seal is far enough away from the sample to avoid excess heating of the sample and yet the completed bulb has a minimum of free space.

The size of the adsorption bulb depends upon the adsorbent. It has been found that for most porous substances 0.2 to 0.5 gm. is a convenient sample size. For substances which are non-porous or which have small specific areas larger samples should be used. *To be continued*

REFERENCES

1. S. Brunauer, P. H. Emmett, Edward Teller, *Journal of the American Chemical Society*, Vol. 60, 1938, page 309.
2. I. G. Joyner, E. B. Weinberger, C. W. Montgomery, *Journal of American Chemical Society*, Vol. 67, 1945, page 2182.

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JOURNAL of the Instrument Society of America

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Vol. 2 MAY 1947 No. 5

Editorial

"BEHIND THE SCENES"

For all Sections except those few whose program activities are carried on the year round, this month—May—will see the last of the technical meetings of the season. Before the opening of the 1947-48 season, ordinarily scheduled for September, the Second National Instrument Conference and Exhibit will have been held in Chicago. For the Chicago Section, at least, the Conference will supplant the regular September meeting of 1947.

Between now and September, however, when most of us are anticipating or enjoying vacations, trips, golfing, fishing and other summer pleasures, many others of us will be busier than ever making preparations for, and taking care of, the myriad details connected with the "Instrumentation for Tomorrow" Conference and Exhibit. A good share of the work is being done by members of the Chicago Section.

Elsewhere in this issue will be found a list of the committees already set up and (in most cases) functioning in preparation for the September Conference. It will be noted that all the committee chairmen listed are Chicagoans. (A few of the committees, including the Educational Committee of which Dr. Teare of Pittsburgh is Chairman, are not indicated in the list mentioned.) When it is realized that each committee listed consists of from three to ten members, most of whom are Chicagoans and with but a few duplications, it will be apparent that a goodly number of Chicago people will have to drastically curtail their normal or planned summer activities this year in order to make possible the Conference and Exhibit for us to visit and enjoy.

The same was true of the Pittsburgh group last year, and the Philadelphia Section will find the same thing true next year.

By the same token, in many other Sections where local plans only are being considered, the summer vacation season is not too much of a vacation for many of the members. The officers, governors, committee chairmen and others will be expending as much or more time and effort then as during any other part of the season in arranging for speakers, programs, joint meetings, meeting places, etc. for the season to come. A good many members and visitors who attend and enjoy the monthly meetings thus arranged sometimes do not realize that a successful meeting doesn't "just happen." Instead of thinking only that "Mr. Doe was the finest speaker we've had this season—his talk was the best I've heard—etc," why not also give some credit to the officers and committee workers who worked hard to provide such an excellent program?

This is not intended to belittle the speaker who, in most cases, spends considerable time and money himself to bring to the meeting an interesting and educational paper, but this may be the only publicity or attention some of the "background" workers ever get. We, personally, cannot help but think that if more of the visitors at our meetings realize to a greater extent what goes on back of the scenes, more of them will join the I.S.A. *in appreciation of the benefits they obtain;* and if more of the rank and file members come to the same realization, more of them will step up and volunteer their services for committee work, etc., and relieve some of the burden on those few "old faithfuls" who carry the load now.

The old saying, "The more you put into the Society the more you will get out of it," is absolutely true (and we use it editorially ourselves quite often) —but it is true only up to a certain point! Some of us put so much into it (and then are asked to do more yet because we are "such willing and dependable workers") that the effort soon becomes a drudge and we are apt to lose interest entirely. If everyone pitches in and does his share, it will not take much of any one person's time, and we can *all* enjoy the Society and benefit from it and its activities as was intended when the organization was conceived.

For the work being done by the various committee workers in preparation for the Chicago Conference (or for any ensuing one, for that matter), the least we can do to show our appreciation is to attend the Conference and express our thanks to as many of the responsible individuals as may be encountered. The workers can not produce a successful Conference unless people come to it, and they will not be too eager to help in future Society affairs unless they know their efforts are appreciated. Let's *all* do our part.

—RRP

Editor's Notes

1. WHO'S WHO—TWO ISSUES BACK!

In the March issue of the *Journal*, the Who's Who column was occupied by President C. O. Fairchild, Delegate Harry Moore, Chairman (of Exhibit Committee) T. G. Robinson, and Chairman (of the Educational Committee) B. R. Teare, Jr. In all write-ups except that concerning Dr. Teare, the above information was included. However, three or four members who evidently follow this column pretty closely have recently asked us what Dr. Teare's position in the Society is (the questioners are probably newcomers, because everyone else knows who Dr. Teare is). Hence we now inform the readers that Dr. Teare is Chairman of the Educational Committee. We beg the readers' pardon for this oversight in the original write-up, and offer our profound apologies to Dr. Teare for having omitted a most important reference in the article.

Skipping now to the current issue, the Who's Who department this time is given over to Dr. R. H. Müller, Chairman of the Research Committee; and Philip Ewald, Chairman of the Emblem Committee. We unfortunately did not receive the material requested from the Delegate we intended to publicize this time, so will include his write-up in a future issue.

At the rate the ISA is gaining new Sections and setting up new committees and sub-committees, we are going to have to start "doubling up" on Delegates and committee chairmen in future issues in order to complete the series of Who's Who articles before some of them are out of office and new ones come along. Readers may therefore anticipate more and more of these articles in forthcoming issues as we re-adjust our schedule accordingly.

2. ONE PUBLICITY PROBLEM SOLVED.

The matter of favorable publicity is given very little thought by many Societies and by some Sections of our own Society, and yet publicity is one of the easiest of Society assets to obtain and one of the least expensive. The I.S.A. receives considerable publicity on a national basis through regular releases from the National Office, but the Sections can and should do their share in order to build up the prestige of the Society. One way to do this is to contribute regularly to the *Journal* which, as a part of *Instruments*, reaches far more readers than just the members of the Society. Another method is illustrated by the following letter from W. A. Reichow, *Journal* Correspondent of the Kansas City Section:

Editor, the *Journal*:

About two years ago the Technical Societies Council of the Kansas City Area was organized. Shortly after the organization, the Kansas City Industrial Instrumentation Society was admitted to membership. We are now affiliated with the Council under the name of "The Instrument Society of America, Kansas City Section."

The Council publishes a monthly official publication, *Pan Tech News*. I am attaching a copy of the March, 1947, issue. You will note on page 4 an article entitled "Instrumentation Comes of Age" by Robert B. Cooke, President of the Kansas City Section of I.S.A.

Since the Technical Societies Council is open only to nationally recognized technical organizations, I believe you would be interested in using this information illustrating the acceptance and progress of the Instrument Society of America.

Very truly yours, W. A. Reichow.

We are interested, indeed, and to the extent that we sought and obtained permission from H. K. Shidler, Editor

of *Pan Tech News*, to reprint the article by Bob Cooke in the *Journal*. It appears elsewhere in this issue under the heading given in Mr. Reichow's letter.

A number of Sections are affiliated with local Technical Societies Councils, most of which are more than glad to publish contributions by member societies. It might be worthwhile for these Sections to make a play for some of this free publicity, and in turn report it to the Editor of the *Journal* for a replay in these columns. If any Section is already enjoying this type of publicity, through Council publications or other media, let us hear about it. Perhaps the experience of one Section will help another into the right channels, and if there are any other publicity-getting ideas floating around, let's get them into the *Journal* where they can serve as examples or inspiration for other Sections to get on the bandwagon.

Many thanks, Mr. Reichow, for your contribution, and congratulations to Mr. Cooke and to the Kansas City Section for a fine bit of publicity gathering.

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Washington—for a concise and timely styling of advance notice information.

(Plus) a lot of little needles, *i.e.*, honorable mention, to Aruba, Baltimore, Central Indiana, Chicago, Southern Michigan and Tennessee for very good reports.

(It is with considerable pleasure that we note a great improvement recently in the Section News reports. We would like to see the trend continue. Maybe one of these days we'll have to turn the Needle around and pick out those reports which lean the wrong way! Do we hear any ideas on the subject?)

—R. R. PROCTOR

General News

INSTRUMENTATION COMES OF AGE

By Robert B. Cooke
President of Kansas City Section
The Instrument Society of America

(Reprinted by permission from PAN TECH NEWS, official publication of the Technical Societies Council of the Kansas City Area, March, 1947, issue.)

Grandma used to make soap in a kettle in the back yard and Uncle Ed flew his Jenny in World War I with a couple of instruments, and navigated it by the seat of his pants.

Today it takes a million dollar kettle and several dozen gages, meters and instruments to produce a bar of soap, but if the ads and operas are right it is pretty perfect soap; by the same token today's giants of the air require a bathroom-sized room of instruments and a flight engineer and two helpers to read them. But we can take off in New York after breakfast and have supper in Paris, and while yet several hours away the pilot knows when he will be there within a few minutes' time.

It didn't take any instruments, other than a clock or a calendar, to make soap Grandma's way, but the exacting standards imposed by competition require an exact knowledge by the manufacturer of his product at any and all points in the process today.

It was probably World War I that brought out the need for quality production in quantity and complete interchangeability of component parts and parallel characteristics of chemical solutions, so that they could be assembled with confidence at a point remote from their origin.

The internal combustion engine and the resultant race for superior fuels and lubricants all demanded complex control systems and equipment.

Instrumentation took its first large stride during that period.

Then came the synthetic age, when man improved on Mother Nature's production machine, and Nylon outmoded the silkworm; coal tars made better lasting dyes than vegetables and herbs; plastics made better gadgets than metal.

In large plants, the "fix-it man" could no longer maintain the dozens of different instruments used, and a group of technically trained men took over the responsibility. The correct application became even more complex, and process engineers made long and detailed studies before their control schemes were correct.

It was now apparent that there was needed unification and standardization of technics and equipment. World War II brought these to a head. A general pooling of "know-how" by industry and science was necessary if we were to achieve the quantity production demanded of America to arm herself and her Allies.

Locally, in April, 1944, individuals representing seventeen different firms in the Kansas City area met and organized the "Kansas City Industrial Instrumentation Society" with the object of the organization being "to promote the art and science of measurement and control of operating processes and their products, whether the units to be measured or controlled be gaseous, liquid, mechanical or electrical energy."

At about the same time in other manufacturing and industrial areas other groups were forming, but (in most cases) without the knowledge of each other's existence.

As the different locals became aware of the fact that there were other groups with similar interests and a common unity of purpose, the American penchant for organizing again displayed itself, and on January 10, 1946 the "Instrument Society of America" was finally organized as the tenth local section ratified the ISA Constitution on that date.

The Society is now comprised of 30 Sections and approximately 2000 members and associates. The rapidity with which the "ISA" has gained both sections and members is ample evidence of the need for such an organization.

The Kansas City Society has managed to maintain its membership with but a very slight drop even though the closing of several large "war plants" in this area brought about a material reduction in the number of instrumentation employees.

The high degree of member interest and participation in its activities is due to the sound principles on which the Section was founded through the untiring efforts of Wm. A. Reichow and Gordon Burke, the true fathers of this group.

The Section President Robert B. Cooke, Vice-President Oliver L. Boutros and Secretary-Treasurer R. Lee Lewis and the members extend a cordial welcome to anyone interested to come out to the Science Building at the University of Kansas City the fourth Tuesday evening of the month and visit the fastest growing technical society in the country.

CLEVELAND MEETING

The ISA members attending the Spring Meeting in Cleveland on April 24th will long remember the very fine program and entertainment provided by the Cleveland Section. The various committees deserve a vote of thanks, the following Cleveland members rate special mention: S. Bousky, H. R. Bowers, M. Estrin, A. A. Hejduk, C. Joy, M. Karns, Harvey Lee, Paul Lewis, A. J. McCullough, J. Prada, W. Sachse, G. E. Sams, J. H. Waldrip and R. Woodside.

The speakers and the titles of their talks are listed below: Harvey Rockwell, Measurement of Light; Nelson Gildersleeve, Progress in Quality Measurement for Process. Control; Gordon Volkenant, Modern Electronic Developments for Automatic Control; W. H. Fortney, Gadgets, Gimmicks, and Ways Out; John Victoreen, Instrumentation in Atomic Energy Research; Dr. Hugh L. Dryden, Measurement—Tool of Science and Industry.

Meetings Schedule

The following committees met on Wednesday, April 23, preceding the technical meeting: Education, Recommended Practices, Finance, Employment, Publication.

On Friday, April 25th, the Executive Committee met at 9 a. m., followed by the meeting of the Board of Directors at 11 o'clock. Reports of various committees were read, discussed and approved, some of which appear elsewhere in this issue. Further details of this meeting will appear in subsequent issues.

Recording Service

A vote of appreciation is hereby extended to the Brush Development Co. of Cleveland, and especially to Pete Odell, Manager of Instrument Sales and a member of the Cleveland Section, for providing two Soundmirror magnetic tape recorders, complete with operators (Brush employees), for recording all proceedings of the meeting. Our thanks to Pete and to his boys for a patriotic gesture and a fine job.

Coincidence

Following the evening program on Thursday, a party in the cocktail lounge found all five editors attending the meeting gathered at one table, with four of them acting as hosts to the fifth—the honored guest and speaker of the evening—Dr. Hugh L. Dryden of the National Bureau of Standards. The publications so represented were the *Journal of Aeronautical Sciences* (Dr. Dryden), *Instruments* (M. F. Behar), *Electronic Industries* (Ralph Batcher), *Industrial and Engineering Chemistry* (Dr. Ralph Munch), and the *Journal of the I.S.A.* (R. R. Proctor).

1947 Exhibit Space Nearly Sold

A report of the Meetings Committee included the very encouraging statement that less than 30 booths remain to be sold out

". . . a buttonhole for every need, I.S.A., A.S.M.E., A.S.Ch.E., Blood Donor, Red Cross, Community Chest, fraternity pins, etc. . . . and oh, yes, a pink carnation!"

of the 154 laid out for the Chicago Exhibit next September.

Membership Report

Dick Rimbach reported that the Society has grown from 1075 members in August 1946 to 2200 members in April 1947!

Official News

Stickers and Cuts Available

To arouse interest in the forthcoming Second National Instrument Conference and Exhibit at the Stevens Hotel, Chicago, September 8-12, stickers and cuts as illustrated herewith are now obtainable at no cost from the National Office. It is suggested that the stickers be used on letters and/or

envelopes for your correspondence between now and September 8, and on other literature, packages, etc. They are printed in red and are gummed ready for use.

For those who would like to print the seal on their letterheads or in their publications, it is suggested that a cut be ordered.

The stickers should be used freely where they will do the most good, but should not be wasted. Place your order for as many stickers as you think you can use, or for cuts, with the Secretary, Richard Rimbach, 1117 Wolfendale St., Pittsburgh 12, Pa.

To All Section Secretaries

Notices of further changes and additions to the previously published list of Section Delegates, Secretaries and *Journal* Correspondents have been received since the last changes were published in the April issue. The following should therefore be incorporated in that list:

1. *Change of address.* Southern Michigan Section, I.S.A., Ken Mead—Secretary, 1919 Buena Vista, Kalamazoo, Michigan.

2. *Change of Correspondent.* South Texas Section, new *Journal* Correspondent is Mrs. Beulah M. Smith. 1448 Southgate Drive, Corpus Christi, Texas.

3. *New Delegate.* Aruba Section, newly appointed Delegate is William F. Hughes, P. O. Box 169, c/o Lago Oil & Transport Co. Ltd., Aruba, Netherlands West Indies. [Ed. Note—We have been advised that Aruba will be represented by their delegate or an alternate at the meeting of the Board of Directors to be held during the Second National Conference and Exhibit in Chicago this coming September!]

4. *New Sections.*

Cincinnati — *Secretary,* R. F. Romell, Vulcan Copper & Supply Co., 120 Sycamore St., Cincinnati, Ohio. *Delegate,* none elected yet.

Louisville—*Secretary,* S. W. Hawkinson, c/o Mpls.-Honeywell Regulator Co., Louisville, Ky. *Delegate,* E. H. C. Brown, 508 Creel Ave., Louisville, Ky.

South Bend—*Secretary,* George Gilliam, 202 Christman Bldg., South Bend, Ind. *Delegate,* none elected yet.

Twin Cities—*Secretary,* Ray Hopper, International Division, Minne.-Honeywell Reg. Co., 2753 4th Ave., Minneapolis 8, Minn. *Delegate,* None elected yet.

Binder Approved

At the meeting of the Board of Directors in Cleveland, a Reference File Binder was approved for distribution to all members, such a binder to be suitably inscribed with the Society emblem and designed to serve as a repository for permanent reference material, tables, data, and other information.

Some of the material to start this binder is to be issued by the Publications Committee with the binder, and it is the desire of the committee to try to satisfy the demand for the supplementary material most greatly desired by the members—and as soon as possible.

This is therefore a request for your ideas. What would you like to see made available as information to be released for inclusion in the binder? Please make your wishes known by sending your suggestions to the chairman of the Publications Committee, Dr. R. H. Munch, 303 Planthurst Rd., Webster Groves, Mo.

Obviously some of such material will require considerable checking and work before publication, and it may not be possible to get it into print soon, but the committee will consider all requests and do its best to oblige the majority demands first.

Summary of Employment Committee Report

Registered Applicants for Positions	
Graduates of Professional Courses..	78
Instrument Mechanics and Technicians	101
Student Registration	5
Consulting Engineers, Meter Services, etc.	13
Total Active Applicants.....	197
Registered Open Positions from October 1946 to April 1947	48
Positions filled by I.S.A.....	15

One of the important points brought out was the fact that there are too few applicants registered with the Committee. Many of the present applicants do not qualify for a specific position owing to education and experience not being directed to the field involved, lack of education and experience, age limits, desire for certain working areas, etc. An endeavor will be made to alleviate this condition by securing applicants from trade and vocational schools and universities. Sections were urged to publicize the employment activity of the Society to employers of instrument men in order to create a greater demand through the Society, and to offer a greater variety of open positions to the members. The Employment Register to be operated in Chicago during the Second Annual Conference will function as outlined in the April issue.

Society Emblem Approved

The final design of the official Emblem of the I.S.A. was approved at the meeting of the Board of Directors in Cleveland on April 25th, and is reproduced herewith about three times actual size.

The emblem is gold with black indications, and is designed to be worn either as a lapel button or as a watch chain key, the latter being slightly larger.

The history of the development of the Emblem is herewith presented in the form of a progress report by Phil Ewald, chairman of the Emblem Committee:

"The Emblem Committee, a sub-committee of the Membership Committee, has functioned informally and by correspondence since its inception. It has held no meetings as such. The task of selecting an emblem representing the objectives of the Society was started by C. O. Fairchild when he was chairman of the Membership Committee by appointing the writer chairman of the sub-committee. Other members of this group are Phil Putnam, Philadelphia, and S. E. Mitchell, Charleston.

"Casual inquiry among I.S.A. members produced a few ideas, but it was decided that the reaction of the membership at large would be desirable. Mr. Putnam, who designed the emblem used by the Philadelphia Section, was asked first to submit some designs. These, plus a few others garnered from other sources, were submitted to *Instruments* for publication. Editor Behar made up a number of drawings of additional ideas, expanded the request for publicity to a full page, and ran it in the August 1946 issue of *Instruments.*

"All received ideas were put on display at the Pittsburgh Conference and Exhibit and a straw vote taken of personal preferences. Since no one idea showed a marked lead over the next best, the novel ideas of the favorites were combined into one and the design submitted to the Board of Directors. Before official action was taken, further designs by S. E. Mitchell of Charleston were considered, and some of his ideas were used to improve the previously 'final' design. The design finally approved is based on the best ideas of all concerned, and should come closest to meeting the ideals of the interested membership, have the most effective advertising value, and be the most generally attractive to all concerned.

"We take this opportunity of publicly expressing our appreciation to the members of the committee for their diligent work, and to all others who were interested enough to submit ideas, suggestions and criticisms, and to those who voted or otherwise responded to our requests for comments on the various designs under consideration.

Philip Ewald, Chairman."

As soon as is practicable, the new emblem will be adapted for use wherever it is appropriate, such as for mastheads, publications, stationery, etc. Cuts will be made available in several sizes, and details on ordering these, as well as pins and keys and their cost, will be published as soon as possible.

Section News

ARUBA

Our 9th meeting was held on April 1, 1947, at the Engineers' Club. President A. S. MacNutt called the meeting to order at 7:15 p.m. Treasurer W. A. Koopman informed us that we were doing satisfactorily in his department, and M. A. Davidson, our representative to the Lago Community Council, presented a short report on the Council meeting of last month.

Details of the "mixed" picnic scheduled for April 15, at which the wives of the members would be guests, were explained by the Social and Recreation Committee Chairman, J. N. Faucett. After a "hot" election, W. F. Hughes was elected our delegate to the Board of Directors of the I.S.A. (The Republicans are strong in this area, too!)

Following the business meeting which lasted for almost an hour and a half, George Echelson gave us an informal talk on Radar, most of which was based on his experiences while attached to the Air Corps during the past war. Echelson's subject certainly held our attention since we spent some 18 months carrying out our job here under "black-out" conditions, and Radar was one of the most important defenses in this area.

To former Captain George Echelson we all heartily joined in with a "well done" at the conclusion of his talk. At this point we stopped to enjoy hot drop donuts and sandwiches, prepared by Mrs. E. H. Pfeffer and Mrs. G. Echelson, and hot coffee by Paul Jensen.

Through the courtesy of the Wright Aeronautical Corporation, we then viewed a sound motion picture, "Cyclone Combus-

tion," which proved to be of interest and was well received. The meeting was adjourned at 10:25. —JIM LOPEZ, *Sec'y.*

BALTIMORE

The Baltimore Section enjoyed several very pleasurable activities during the month of March beginning with the regular meeting which was held at the Engineers' Club on Friday evening, March 7.

At this meeting 73 members and guests assembled to enjoy the honor and privilege of hearing a speaker who has won world-wide recognition as an authority on Flow Measurement, L. K. Spink, Head of Flowmeter Engineering of the Foxboro Company, Foxboro, Mass. Spink, who is the author of several books on flow measurement as well as the inventor of several calculating instruments, connections, and control instruments, spoke on the subject "Flow Engineering." His talk, illustrated with slides, was very instructive as well as interesting. Attention was called to the present trend toward continuous rather than batch processes, which places more and more emphasis on the rate type of meter. Following a discussion period during which Spink graciously answered questions and explained some of the more difficult points, refreshments were served.

On Tuesday, March 11, the Council of Officers held a business meeting at the close of which a farewell party was given at Munders Lauraville House for Byron Dewey, formerly of Petroleum Chemicals, Inc., who is leaving Baltimore to take charge of instrumentation for the Airco Plants of the Air Reduction Company of Stanford, Conn. Dewey, who was chairman of the Membership Committee, always took an active interest in I.S.A. activities and the Section deeply regrets seeing him leave.

On Friday, March 21, 35 members and guests were conducted on a field trip through the plant of the Crown Cork and Seal Company, which all enjoyed greatly.

—KENNETH R. MILLER, *Corr.*

CENTRAL INDIANA

Members of the Central Indiana Section enjoyed a very interesting illustrated talk on "Measurement and Analysis of Sound and vibration" at their regular meeting on April 8. The speaker, William R. Saylor of the General Radio Company, explained to the group the operation and uses of sound level meters and sound analyzers, and the method of making use of a parallel T network in these instruments. Operation and uses of vibration meters and vibration analyzers were also explained.

Saylor had these various pieces of equipment with him and they were inspected by the members with great interest. Kipling Adams, of the Chicago office of General Radio Company, assisted Saylor in demonstrating and explaining the instruments.

L. Gess, of the Brown Instrument Company, will give a talk on Flow Meters at the May 1st meeting of this Section. At the June 3rd meeting Robert Miller, Supervisor of the Elgin Observatory, is scheduled to give a talk on "Measurement of Time." The program will include a showing of the motion picture "Time."

—M. W. HANSON, *Corr.*

CHARLESTON

Monday, May 5, 1947—"Combustion and Feedwater Control," by C. H. Barnard, Bailey Meter Company.

CHICAGO

The regular April 7 meeting of the Chicago Section featured an inspection trip through the Northwestern Technological Institute at Northwestern University, and claimed the record for attendance at any meeting this year. Over 140 members and friends enjoyed the dinner meeting at the Georgian Hotel in Evanston, and 160 made the trip through the Institute.

The dinner meeting at the hotel featured brief addresses by Dean Eshbach and Dr. Klopsteg of the Institute, both of whom discussed the activities and plans of the Institute with special emphasis on instrumentation activities.

At the Institute a number of laboratories were open for inspection, and the guests were free to visit those activities which were of greatest interest. Judging by the interest aroused, the electron microscope, chemical instruments, technical measurement, control systems and the microwave laboratories were highlights of the tour. In addition to these laboratories, others in the departments of Civil Engineering, Mechanical Engineering, Electrical Engineering and Physics were open. Members of the staff and graduate students were on hand to describe the equipment and, in a number of cases, demonstrations were carried out.

Arrangements for the inspection trip were made by R. W. Jones, Associate Professor of Electrical Engineering, Northwestern Technological Institute, who also acted as technical chairman at the dinner meeting. The event was enjoyed by all.

Two meetings are planned for May, one scheduled and the other unscheduled. The latter is a "Users' Pep Meeting" at which the views of the users of the Section are to be aired, with special emphasis on the types of programs preferred, policy, how to interest more users in joining, and how to promote greater user activity in committee work, program participation, etc. This meeting is to be held May 5. The regular May meeting is to be held May 12 at the Furniture Club of America, and will be a combination Annual Business Meeting and Social Night with entertainment. This meeting is for the ladies, as well as for the members and guests.

—JOHN C. VAALER, *Corr.*

DETROIT

The March meeting of the Detroit Section featured F. R. Brydges, Instrument Engineer for the Post Products Division of General Foods Corporation, and P. C. Skeels, head of the electronics division of General Motors Proving Grounds.

Brydges, in his talk on "Unusual Control Problems," outlined four basic systems and discussed several practical methods of instrumentation applicable to flow and liquid level measurement and control. He concluded his talk by listing these four types of control assignments given to instrument engineers:

1. Set up a control system but don't spend any money!
2. Improve the present system as cheaply as possible.
3. Re-establish control by any means but keep the process going.
4. Design and build best possible system regardless of cost and time.

Skeels' illustrated lecture on "Electronics Applied to Counting Problems" described and demonstrated an interesting electronic counter used for counting revolutions of test engines but adaptable to many other applications. This instrument can faithfully indicate rates as high as 200 counts per second, and may be actuated by impulses as small as the radio signals emitted by an automobile ignition system..

In a short business meeting prior to the evening's talks the proposed by-laws of the Section were presented to the membership by the Executive Council. After some discussion they were unanimously accepted as amended. Chairman of the By-Laws Committee Emil Gillig was commended for his fine job. Several members of other Sections attending the meeting requested copies of these new By-Laws; additional copies may be obtained by addressing Secretary, Victor G. Raviolo, Ford Motor Company, Village Rd. Bldg., Dearborn, Mich.

Chairman Milton Weber of the Membership Committee reported that the Section membership had, reached 100. His committee's goal is 150 members by June.

Our April 28th meeting was addressed by O. G. Rutemiller, Consulting Engineer, who spoke on "The Motron Servomechanism." The April demonstration featured Wheelco Temperature Control Instruments and Combustion Safeguard Equipment, with C. L. Clark in charge. On May 26, Dr. M. E. Nichols, of the University of Michigan, is scheduled to talk on "Telemetering Problems in Flight Research." On June 23, the subject of "Automatic Controls for Production Machinery" is to be discussed by representatives from the following companies: Micromatic Hone Corporation, Monarch Machine Tool Company, and Moore Products Company. —SIEGMUND KULKA, *Corr.*

EASTERN NEW YORK

The Eastern New York Section held its April meeting on Tuesday evening, the 8th, at Siena College, Loudonville, New York.

We were honored twofold by having J. E. McMahon who, in his capacity as Vice-president of the I.S.A., extended the greetings of the national organization, and then assumed his role of speaker for the evening, presenting a very enlightening talk on "A Non-Mathematical Discussion of Flow Measurement." The lengthy question period which followed his talk was proof in itself of the enthusiastic reception of his talk. The meeting did not break up until 10:30 p.m.

At our May meeting we will hear about the goings-on "Behind the Instrument Dial" as described by Lawrence Parachini, Manager of Educational Activities and Public Utility Sales, Weston Electrical Instrument Company, Newark, N. J.

—W. J. CLAFFIE, JR., *Sec'y.*

KANSAS CITY

Our March meeting was held on the 25th at the University of Kansas City. The speaker of the evening was Dr. George Ziegler, Executive Scientist of the Midwest Research Institute of Kansas City. His subject was "Today's Research—Tomorrow's Industry."

Following his short paper which outlined the work being done at the Institute, the members and guests were taken on a personally conducted tour of the Institute. Here, Dr. Ziegler showed us at first hand the work being done with special emphasis on the part that instruments play in research.

The Midwest Research Institute is backed generally by Kansas Citians, and in particular by the industries in this territory. Consequently it is doing considerable research in furthering the use of the natural resources of this area, particularly foods. However, the Institute is also engaged in developing industrial items which are at the present time being manufactured outside the Kansas City area.

Our May 27th meeting will feature J. L. Cottrell of the Pittsburgh Meter Division of Rockwell Manufacturing Company, who will talk on "Orifice Meters and Their Installation."

It should have been noted previously that our elected President, Robert Cooke, had to resign because of a change in employment which took him away from Kansas City. V.P. Oliver Boutros has consequently assumed the Presidency of the Section for the remainder of the season.

—R. L. LEWIS, *Sec'y.*

LOUISVILLE

The Louisville Section April meeting was addressed by V. V. Twig, Foxboro Co. on "Derivative Control." It was agreed by all concerned that such a program as given by Twig was well worth holding the meeting at high noon if it would suit his convenience.

This meeting marked the passing of the fifty paid-up-members mark, and we are now shooting for a hundred.

—E. H. C. BROWN, *Pres.*

NEW JERSEY

The usual zest for argument was missing at the Forum Meeting held at the Essex House on April 1 by the New Jersey Section. Perhaps the fact that it was April Fool's Day made everyone a little hesitant; however, there were some good topics introduced for discussion and the meeting was attended by an unusually large group.

Harry Moore, who with Bill Ludi and Dick Roberts served on the Nominating

mmittee, announced the following slate the coming year:

For President: Sid Baran of R.C.A.
Vice-Pres.: Herb Close of National Lead Co.
Secretary: George R. Feeley of Trinity Equipment Corp.
Treasurer: Walt Maurer of Taylor Instrument Co.

Elections will be held at the May meeting, Tuesday, May 6. The speaker at this eeting will be Bruce Irwin of Hammelahl Company, who will talk on "Control alve Application." As this will be the last eeting of the year at the Essex House efreshments will be served after the meetg to celebrate the conclusion of a very ccessful year.

The June meeting will be an inspection ip through parts of the Calco Chemical ompany, and along with announcements the May meeting, return post cards will sent out for reservations for this meetg. As the dinner will be served at Calco, will be necessary for all those wishing to tend to make reservations in advance. If embers encounter any problems in conection with making reservations, get in uch with John Kelly of Calco Chemical o., Bound Brook, N. J.

—GEORGE R. FEELEY, *Corr.*

NEW YORK

The 48th meeting of the New York Section was held at the Men's Faculty Club at olumbia University on Monday, March 31. ixty-six members and guests were present r supper.

The business portion of the meeting conisted of several announcements by Presient Hildenbrand, the reading of the minutes of the previous meeting and the anouncement by the Program Chairman, alph Batcher, that the topic of the next eeting would be "Instrumentation in Russia."

Professor Kayan, as technical chairman, troduced the speaker for the evening, Dr. C. Mouzon of Brown Instrument Comany, Philadelphia. The subject, "Industrial Applications with Electrical Resistance Methods," was well presented. In eneral, it was a survey of the field of easurement where resistance changes are ccomplished by changes in such parameters as temperature, pressure, magnetic eld and light. Means of measurement of esistance and of amplification of the effect were explained. Several demonstrations were presented to illustrate various onditions affecting resistance.

The meeting adjourned at 10 p.m.

—CHARLES D. COREY, *Corr.*

OAK RIDGE

The regular April meeting of the Oak Ridge Section, held on April 1, featured J. A. Michaelson of the General Electric Company of Schenectady, N. Y. The dinner portion of the meeting started at 7 p.m., followed by the business and technical meetings.

The subject of Michaelson's talk was "New Developments of the General Engineering and Consulting Laboratories." The discussion was well illustrated with a number of slides.

The business meeting was called to order at 8 p.m. by President A. V. Novak. The minutes of the last meeting were read by Secretary A. H. Fowler, and H. V. Fisher, as chairman of the Program Committee, reported on the activities of his committee. Chas. W. Covey presented a report on the activities of the Publicity Committee, of which he is chairman. A lively discussion of a forum series exclusive of the regular meetings was carried on with no definite conclusions being reached. It was announced that the discussion would be continued at the next meeting with more details available to bring the question to a desirable conclusion. N. L. Isenhour, National Delegate, spoke briefly concerning the recent activities of the National Office.

The speaker of the evening was introduced by the chairman of the Publicity Committee, C. W. Covey. The photometer and a photo-recorder were described. A high speed electron counter was discussed and its application as a projectile counter pointed out. An electronic wide-band frequency meter was also described. Actually a tachometer, the instrument can count up to 60,000 rpm. An electro-mechanical measuring gage was discussed, and the G. E. Torque-meter and the Vapor Detector were explained. A new Dew-Point Recorder was described from a schematic on the screen. The photographing of projectiles and shock waves with an electronic stroboscope was explained and several interesting photographs were shown on the screen.

An interesting informal discussion followed the technical portion of the meeting.

Dr. H. A. Straus of Monsanto Chemical Company, Oak Ridge, will speak on "Servomechanisms" at the May meeting.

V. D. Hauck, Chief Engineer of the Friez Instrument Division, Bendix Aviation Corporation, will speak at the June meeting on "Radio Sonde—Present Status of the Art."

A seminar is currently planned for the July meeting. —CHAS. W. COVEY, *Corr.*

PHILADELPHIA

(The following items were taken from the mailed announcement of the April meeting, as no formal report was submitted this time —ED.)

46th Meeting, Wednesday, April 16, 1947. "Liquid Level Measurement and Control by Variable Displacement," by Paul Wing, Jr., Mason-Neilan Regulator Co.

May meeting, Wednesday the 21st. "Industrial Electrochemical Measurement and Control" by Dr. Willard N. Greer, Ph.D., Leeds & Northrup Co.

PITTSBURGH

The March meeting of the Pittsburgh Section was held on Monday, March 24, at the Carnegie Library lecture hall. Eighty members attended. A technicolor picture produced by the Lindberg Engineering Company entitled, "Heat Treating of Metal Parts" was shown. This was followed by a brief business meeting. Charles Cochrane of the educational committee announced the distribution of questionnaires to be used in determining the demand for a training course for instrument mechanics to be inaugurated in the vocational departments of the Pittsburgh public school system next year. Jacobs of the nominating committee announced the names of nominees for next year's officers and introduced the nominees. Wayne Farley was appointed chairman of the new Trip Committee whose function will be to arrange tours through various plants in the Pittsburgh district. At the conclusion of the business meeting O. F. Benson of the American Meter Company, Inc., gave a talk on "Flow Measurement."

The next meeting of the Section will be held on Monday, April 28, 1947. The subject "Automatic Proportioning of Gases and Liquids," will be presented by B. J. Velten, Askania Regulator Company, 1603 So. Michigan Avenue, Chicago 16, Illinois.

For the May 26th meeting, John C. Whiddett, of Automatic Temperature Control Co., Inc., is scheduled to speak on "Time Controls in Industry."

—A. G. YOUNG, *Corr.*

ST. LOUIS

The St. Louis Section held its regular March meeting at the York Hotel in St. Louis on Monday, March 31, 1947. Attendance was approximately 75 members and guests.

D. P. Parker, Manager of the Technical Department of the East St. Louis refinery of the Socony-Vacuum Oil Company, was the speaker of the evening. He covered the importance of petroleum products during the late war, when the army literally "moved on its petroleum products." Sixty percent of the weight of all material shipped to the army in the field from this country consisted of products derived from petroleum!

Parker pointed out that petroleum was known in prehistoric times, and was used for medicinal purposes, tracing the development of petroleum refining up to the present time, listing the dates of the advent of the more important products. The fact that modern refinery operations are peculiarly adapted to automatic control and instrumentation was brought out by Parker with the aid of many excellent drawings and slides. All types of temperature, flow, liquid level, pressure and other indicating and control instruments are used, as well as some instruments not known to other industries. The talk, entitled "The Role of Instruments in Petroleum Refining," was very interesting and well presented.

W. C. Rosenbaum announced that the St. Louis Section's Employment Committee has several openings available, and requested employers and instrument men to take advantage of the committee's facilities.

The regular meeting scheduled for Monday, April 28, will feature Louis Gess, Brown Instrument Company, who will speak on "Flow Meters—Design and Application."

On Monday, May 26, special entertainment is to be provided as a feature of the "Season's End Party."

—H. E. ZEFFREN, *Corr.*

SOUTH BEND

The regular monthly meeting of the South Bend Section was held on April 17 at the Engineering Building, Room 5, University of Notre Dame. H. C. Frost, Assistant Director of Research, Chemical Division, Corn Products Refining Co. of Chicago, Ill., presented a paper entitled "Some Considerations in the Control of a Continuous Process." Frost covered a typical continuous flow process, stressing the importance of coordination between the development of the chemical process and the instrumentation needed to indicate, record, and control that process.

The next meeting will be held at 7:30 p.m. on May 22 in Room 5, Engineering Building, University of Notre Dame. Dr. Karl Schoenherr, Dean of Engineering of the University of Notre Dame will cover some aspects of the instrumentation problems encountered at the David Taylor Model Basin during the war.

—GEORGE GILLIAM, *Sec'y.*

SOUTHERN MICHIGAN

Sixty-three members and guests attended the April 16th meeting of the Southern Michigan Section at Chicken Charlie's in Kalamazoo. President Wade Allen opened the meeting by introducing the new members and out-of-town guests. Eight applications for new membership were received before the meeting.

Program Chairman Oliver Woods then introduced the speaker of the evening, Carl Lee, Chief Engineer of Radio Station WKZO, Kalamazoo, who discussed the timely subject of "Frequency Modulation." Lee covered the early development of FM transmission, explaining the difficult time Armstrong (the inventor of the FM principle) had in securing a station license.

Some of the merits listed for FM were static elimination and high fidelity. Lee explained that less power is required to keep the signal-to-noise ratio in line for good reception, but that the standards required of the FM broadcasting station far exceed the standards set up for receivers. He also showed that there is room for 4000 FM stations in the new 88 to 108 megacycle FM band, as compared to only 1200 AM (Amplitude modulation) stations in the 550 to 1500 kilocycle band.

Lee then demonstrated the Brush Magnetic Tape Recorder. We listened to a recording of a news broadcast, a band and an organ. He then made a recording of some of the members talking, and played it back immediately—producing a big laugh among those present. A lively discussion period followed.

At the May 14th meeting, Theodore A. Cohen, President of the Taco-West Company, will discuss "The Electronic Phases of Automatic Control Apparatus" and special problems of pyrometry.

—KEN MEAD, *Corr.*

TENNESSEE

The 23rd meeting of the Tennessee Section, ISA, was held at the Civic Auditorium in Kingsport, March 12, 1947, with dinner at the Kingsport Inn before the meeting.

Business consisted of a discussion of the program for the balance of the year. The method of handling nominations of candidates for office was reviewed. The May meeting was announced as the annual business meeting and all members were urged to be present. The section was fortunate in having present J. B. McMahon, National Vice president who took an active part in the business discussion and answered many questions pertaining to national policies.

McMahon then presented his talk on "A Non-mathematical Discussion of Flow Measurement." Starting with the history of flow measurements, he continued through the various stages of tests and development to the most recent accepted standards. Proper installation methods were stressed. An interesting discussion of the subject followed his talk.

The April 9th meeting was also held at the Kingsport Inn in Kingsport, Tenn. Business consisted of a general discussion of grades of membership with corresponding benefits. Progress of the membership drive committee was reported by George Moorehouse, Chairman.

Henry W. Stoll of the Taylor Instrument Companies, Rochester, N. Y., was the principal speaker. Interest in his discussion of "Flow Measurement" was intense. Questions from the floor, followed by Mr. Stoll's timely solutions, directed the course of his talk.

The May meeting will be the annual business meeting. Election of officers will be held then. —F. H. THEILE, *Sec'y.*

WASHINGTON

The next three meetings of the Washington Section are scheduled as follows:

April 21. Chas. S. Packard, Chief Engineer of Struthers-Dunn, Inc. will address the Section on the subject "Electrical Operation of Small Mechanisms."

May 19. George W. Baughman, Chief Engineer, Union Switch & Signal Company, will talk on the subject "Railroad Instrumentation." His discussion will cover electronic equipment developed to increase reliability and safety of signaling devices on the railroads. As an added attraction, a 30-minute color movie depicting the interesting history of the railroading industry will be shown. This General Electric picture entitled "Railroadin'," was released by General Electric and the American Locomotive Company, and took over a year to produce. The program promises to be one of the big attractions of the year.

June 9. Anthony H. Lamb, Chief of the Relay and Thermometer Engineering Division, Weston Electrical Instrument Corporation, will be the speaker. His subject w cover the development and applications the Photronic Cell and associated circ components such as sensitive relays, ma ingenious models being developed by We ton during the war. Lamb contributed mu to the development of the Photronic C and the Sensitive Relay. His talk will followed by a short movie which will reve the intriguing marvels of the "phototub and which demonstrates many commerci applications.

—E. L. DEETER, *Chmn. Meetings Com*

WAYNE COUNTY

The Wayne County Section of I.S.A. m on April 21, at the Presbyterian Chur House in Wyandotte, Mich. The dinner w held at 6:30 and the meeting at 8:00.

The meeting was opened with the dra ing of the door prizes.

The following officers were elected f the coming year: George Huff, President Charles Chessrown, 1st Vice President Robert Wright, 2nd Vice President; Geor Rogers, Secretary; Fred Munchausen, Tre surer.

The speaker of the evening was H. W Auraz of the Brown Instrument Co., wh gave a very interesting talk on "Some Pra tical Aspects of Automatic Control."

Our next meeting will be on May 19th a which time T. A. Cohen will talk on "Ele tronic control." —W. S. BAKER.

Who's Who in the I. S. A.

PHILIP EWALD

Since the official emblem of the Instrument Society of America was approved at the meeting of the Board of Directors in Cleveland on April 25, it is appropriate to devote a portion of the "Who's Who" department in this issue to the man who is responsible for the development of the final design of the emblem, Philip Ewald, Chairman of the Emblem Subcommittee, of Sheffield, Alabama.

"Phil" was graduated in Engineering Physics in 1935 from the University of Michigan, and almost immediately afterward joined the TVA Department of Chemical Engineering at Muscle Shoals, Alabama. His work there has been principally instrumentation, including design and installation of instrument systems for large scale chemical processes, organization and supervision of research and plant instrument laboratories, and research and development work on instruments for special applications.

Indulging in his hobbies is a serious business with Phil. He has been an amateur radio fan since high school days, and is known on the air as W4EWR. Since his college days he has also been a gliding and soaring enthusiast. In addition, he indulges in hunting, fishing and boating on TVA lakes, miniature photography, clarinet and phonograph records, and writing for technical journals! As to where he finds time for all this, Phil explains by saying that he is still an active member of the local Bachelor Club.

He is a member of I.S.A., A.C.S., A.P.S. and A.A.A.S., and of the hobby organizations A.R.R.L., Soaring Society and C.G.A. He is a member of the I.S.A. Membership Committee, and was appointed in 1946 by President Fairchild (then chairman of the Membership Committee) to head the subcommittee to secure an emblem for the Society. That it has taken so long to complete the task is no fault of Phil's, as is shown in the report of the committee's activities elsewhere in this issue.

R. H. MÜLLER

Dr. Ralph Holcombe Müller, Chairman of the Research Committee, has been engaged in the teaching and direction of research in various branches of instrumentation for the past sixteen years. His early training was in chemistry; he obtained his B.S. degree from Pennsylvania in 1922, and his M.A. and Ph.D. from Columbia in 1923 and 1925 respectively. In 1927 he engaged in post-doctoral research in physics in Göttingen.

Dr. Müller has published research in radiation, photoelectric photometry, electronics, instrumental methods of analysis and the design of scientific and industrial instruments. He was associated with New York University from 1924 to 1942, where he still holds the rank of Professor of Chemistry. From 1942 to 1946 (June) he was engaged in research and field engineering in radar at the Radiation Laboratory of the Massachusetts Institute of Technology.

Since January of 1946 he has been Contributing Editor on "Instrumentation in Analysis" for the Analytical Edition of *Industrial and Engineering Chemistry.*

The Research Committee, of which Dr. Müller is chairman, functions to recommend and expedite the carrying out of research problems in various fields of instrumentation. The committee to date has been engaged in a careful "feeling-out" of its fields of usefulness, and a forthcoming progress report will be published as soon as it becomes available. Other members of this committee are M. F. Behar (Pittsburgh), C. F. Kayan (New York), T. R. Harrison (Philadelphia), and Ed S. Smith (New York).

ISA EMPLOYMENT SERVICE

In printing these announcements the Society assumes no obligation as to responsibility of employers. Those replying to announcements should include two copies of their reply. When testimonial documents are to be included, copies of such documents and *not* the originals should be sent. The Society regards acknowledgment by employers of all applications as an act of courtesy but can assume no responsibility for their failure to do so. Address all replies to Employment Committee, Instrument Society of America, 1117 Wolfendale St., Pittsburgh 12, Pa.

—C. F. GOLDCAMP, *Chmn. Employ. Com.*

SITUATIONS OPEN

INSTRUMENT MECHANIC by large process manufacturer to service Hays automatic control on three 800hp. Erie boilers, CO_2 recorders, flow meters; temperature recorders on dryers, cooking kettles and kilns. Must be able to make efficiency checks throughout plant. Salary $250.00 per month. Location Southern Illinois. Box 49.

. . .

INSTRUMENT MECHANICS for maintenance and repair of all types of oil refinery instruments including flow controllers, temperature and pressure regulators, etc. Give detailed outline of previous experience, as well as complete personal information. Hourly basis. Permanent. Location East Central United States. Box 50.

. . .

ENGINEER, young man with some knowledge of instruments and air operated diaphragm control valves as salesman to work out of New York District office of old established manufacturer. Box 51.

. . .

PHYSICIST or **ENGINEER**, A.B. or B.S. degree in radio or electrical engineering to assemble, calibrate, and repair instruments used to measure radiation. Also to conduct radiation surveys. Headquarters New York City but must be in a position to travel. Civil Service appointment. Salary $4,900.00 plus transportation and travel allowance. Box 52.

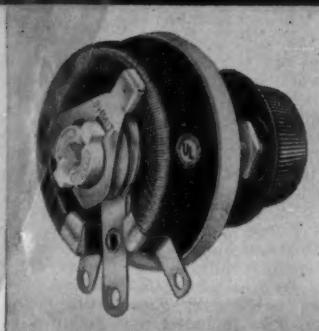
. . .

CHEMICAL ENGINEERING Ph.D. for Assistant Professorship in Chemical Engineering Department of midwestern University. Must have experience in instrumentation as opportunity will be afforded to develop this specialty within the department. Box 53.

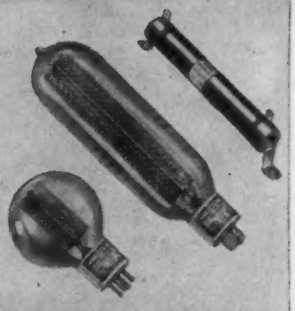
Be Right with.. OHMITE

Vitreous Enameled Rheostats

Available in 10 sizes, ranging from 25 to 1000 watts, in a wide range of resistances. Ceramic parts insulate the shaft and mounting. The resistance winding is permanently locked in vitreous enamel. The metal-graphite brush provides unmatched smoothness of action. Engineered and constructed for long, trouble-free life.



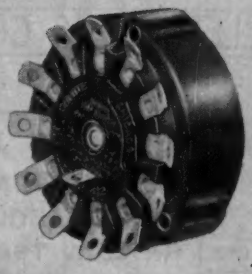
Non-Inductive Resistors



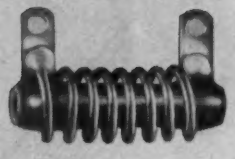
Used as dummy antennas for radio transmitters, load resistors in high frequency circuits, and terminating resistors for radio antennas. Available in vitreous-enamel type wound on a tubular ceramic core and in hermetically sealed-in-glass type mounted on a 4-prong steatite tube base. Sizes from 50 to 250 watts.

All Ceramic Tap Switches

A popular switch for use with tapped transformers in power supply units. Compact, dependable, and convenient to operate. Available in ratings of 10, 15, 25, 50, and 100 amperes, A.C. Contacts are of the silver-to-silver, non-shorting type. Switch shaft is insulated by a strong ceramic hub. The heavy, one-piece ceramic body is unaffected by arcing.



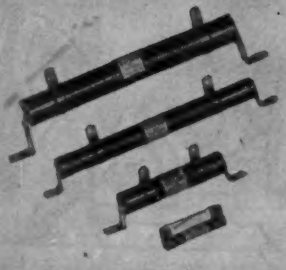
Parasitic Suppressor



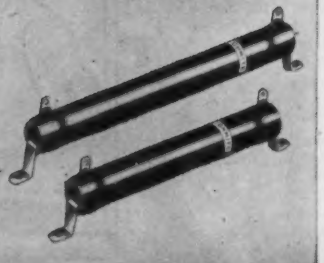
Designed for the suppression of unwanted ultra-high frequency parasitic oscillations due to incidental resonance between tube plate and grid circuits of push-pull and parallel operated transmitting amplifiers. Consists of a 50-ohm vitreous enameled non-inductive resistor which supports a choke of 0.3 microhenries and .003 ohms d-c resistance.

Radio Frequency Plate Chokes

For use in the plate circuits of diathermy oscillators and amateur, aviation, police, and commercial short wave transmitters. Consists of a single layer winding on a steatite core, rigidly held in place, insulated and protected by a moisture-proof coating. Rated at 1 ampere.



Wire Wound Resistors



Ohmite offers a complete line of dependable resistors wound on a ceramic tube and protected by vitreous enamel. Ratings from 10 to 200 watts. Available in the fixed type for general use, and in the "Dividohm" type with adjustable lugs for use as a multi-tap resistor or voltage divider.

OHMITE MANUFACTURING CO., 4886 Flournoy St., Chicago 44, U. S. A.

OHMITE

Write Today for Ohmite Catalog No. 18

Provides 16 pages of useful data on the selection and application of rheostats, resistors, tap switches, chokes, attenuators, and other equipment.

Technical Society News

AKRON INSTRUMENT SOCIETY

No report of our February meeting was sent in due to the illness of Ye Scribe, and our March meeting was blown away with the blizzard, but the Akron Instrument Society is very much alive and kicking.

The April meeting was held at the Akron YWCA on Tuesday, the 25th, with 45 members and guests present. Speaker for the evening was Mr. Paul Wing, of the Mason-Neilan Regulator Co. His subject, "Control Valves," is one which every instrument man knows all about (of course!) but he was surprisingly able to bring out a number of facts which were new to us—and which gave us a better perception of the important part played by the lowly valve tucked away somewhere on a pipe line.

Mr. Wing pointed out that on open-closed service, strength of spring is a simple matter but, on close throttling control, springs have to be carefully engineered, taking into account size of seat, size of top, pressure in line and pressure drop to be absorbed by the valve. The question of pressure drop is an important one, a 150-lb. drop being the maximum desirable for standard service. Pressure drops above this require special consideration for satisfactory performance.

Regarding single- and double-seated valves, Mr. Wing stated that type of service is the determining factor. Where tight shut-off is essential, single seats are best, as double-seated valves require special grinding technique to be tight-seating; whereas, for modulating control, double seats are best, owing to inherent force-balance characteristics.

The next meeting will be on Tuesday, May 27th, time and place to be announced later. The speaker will be Mr. L. V. Parsegian, of the C. J. Tagliabue Co., and his subject "Principles of Potentiometer Pyrometers." —FRED APPEL, JR., *Sec'y.*

BOSTON INSTRUMENT SOCIETY

The Boston Instrument Society met at 6:30 p. m., April 9th at Thompson's Spa in Boston.

Mr. J. B. McMahon of the Republic Flow Meters Co., Chicago, Ill., and Chairman of the Committee on New Sections of the Instrument Society of America, had as his subjects:

(1) Shall we join the I.S.A.?
(2) A non-technical address on Flow Measurement.

Mr. McMahon stated the many advantages to be gained by having our Society join the I.S.A. He described the different membership classifications and answered questions in regard to the present and future plans of the I.S.A. His address on Flow measurement was well received by our members.

Mr. H. S. Fairchild who presided, announced that at the May meeting which will be the last until September, there will be the election of officers and a vote will be taken on joining the I.S.A.

—J. H. CONDON, *Corr. Sec'y.*

SOUTHERN CALIFORNIA METER ASSOCIATION

The May meeting of the Association will be held at the usual place, Rio Hondo Country Club on Thursday evening, May 22. Dinner will be served at 6:30 and the meeting will start at 8:00.

Mr. Warren of the Mineralight Black Light Products Company will speak on "Ultraviolet Light in Prospecting and Industrial Applications." There will be a supplementary program of general interest.

An excellent turn-out was had for our April meeting at which Mr. Claude Nolte, Manager of Sales for the Barton Instrument Company, spoke on "The Sizing of Control Valves." —CHARLES MERIAM

AIR NAVIGATION FACILITIES

William A. M. Burden, Assistant Secretary of Commerce, in a speech at the Aviation Dinner Meeting of the Society of Automotive Engineers in New York, declared that "the greatest single factor in achieving a really major improvement in safety and regularity lies in the improvement of our system of air navigation facilities. The improvement of those facilities involves the solution of two problems: a financial problem and a technical problem. . . .

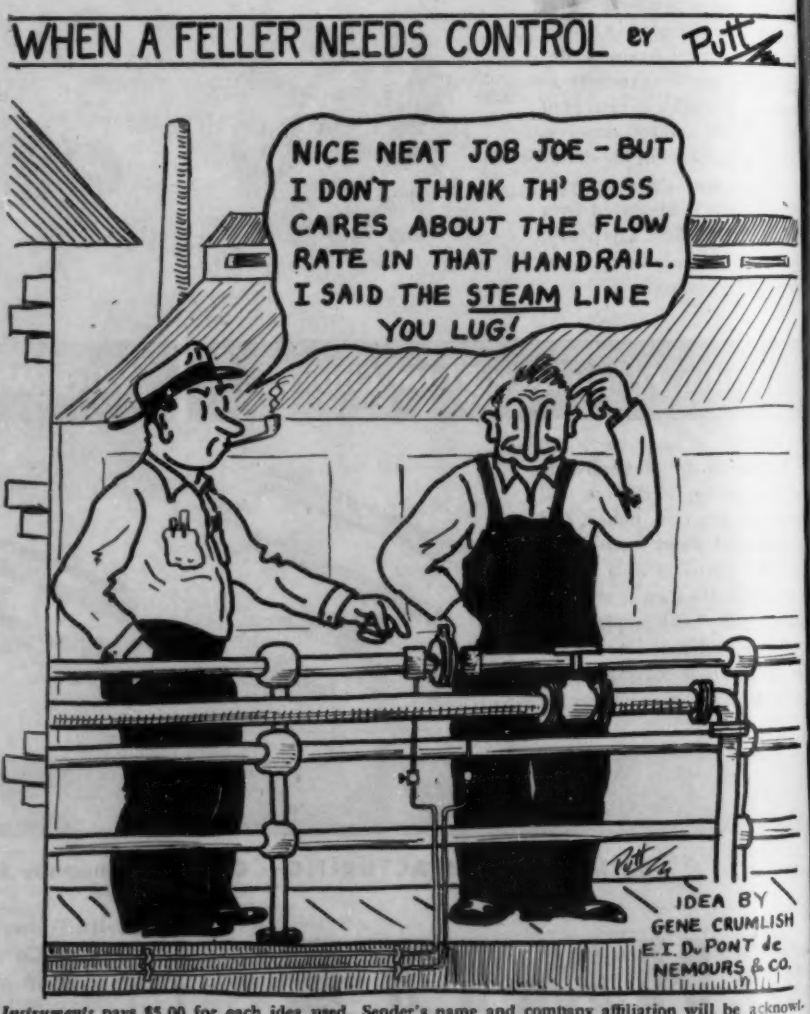
"The government is facing the necessity of large additional capital expenditures on the airways and increased expenditures on research if it is to do its job of developing civil aviation properly and is to reap the economic returns that will come from a rapidly-growing air transport industry. The radio facilities which comprise the airways system are largely obsolete. Most of them were designed fifteen years ago. The first stage of a program for the replacement of the low-frequency ranges with modern VHF types and the widespread installation of instrument landing systems and approach light lanes was included by the Congress in CAA's budget for fiscal 1941. Then came the war during which the armed forces quite properly obtained the entire output of the United States radio industry. And after VJ-day, although Congress included substantial sums for VHF and ILS installations in our fiscal 1946 budget, the deliveries of equipment by the radio manufacturing industry have as yet been only a trickle. . . . The war and its aftermath, reconversion, have thus produced a delay of nearly five years in the practical modernization of our airways system. . . .

"There is no doubt that the sums expended by our government on the airways system and in the support of civil aviation generally have proved a good investment just as our federal expenditures on highways and our land-grant aid to railroads have been a good investment in building up great industries which have made this country what it is today. . . .

"As I need not remind you engineers, one must avoid the temptation of calling a halt to orderly progress every time a promising new gadget glimmers over the horizon. . . .

"The CAA-industry program for improved instrument weather approach facilities has been carefully evolved and contains all the elements which are now so actively highlighted in the public press—ILS, GCA, high-intensity approach lights and radar tower surveillance. . . .

"The equipment of large numbers of key airports with ILS, GCA, high-intensity light and even a very few with FIDO will require a very substantial investment, probably 20 to 40 millions. I believe it will be a sound investment. . . ."

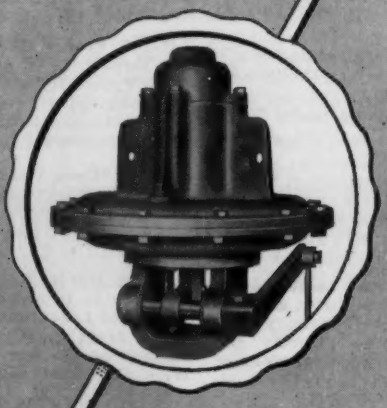

WHEN A FELLER NEEDS CONTROL
BY Putt
NICE NEAT JOB JOE - BUT I DON'T THINK TH' BOSS CARES ABOUT THE FLOW RATE IN THAT HANDRAIL. I SAID THE STEAM LINE YOU LUG!
IDEA BY GENE CRUMLISH
E. I. DuPONT de NEMOURS & CO.

Instruments pays $5.00 for each idea used. Sender's name and company affiliation will be acknowledged in the cartoon unless we are specifically requested not to do so. Address Cartoon Dep't, *Instruments*, 1125 Wolfendale St., Pittsburgh 12, Pa.

SERIES 600

DIAPHRAGM AIR MOTORS

Furnished as one unit — complete with North American Adjustable Port Valves.



Used with pneumatic type instruments for throttling control of air, gas, oil, water or steam.

Adjustable Port Fuel Valve and Motor

Butterfly Air Valve and Motor

Adjustable Port Air Valve and Motor

by NORTH AMERICAN

For Combustion

THE NORTH AMERICAN MFG. CO.

GAS OR OIL COMBUSTION EQUIPMENT • BRANCH OFFICES IN PRINCIPAL CITIES

CLEVELAND 5, OHIO

FLOW RATE METER ELIMINATES "BUBBLE COUNTING"

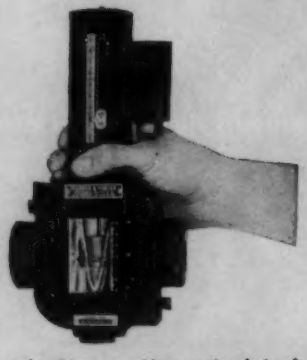
This compact flow meter is the answer to purge line (Bubbler) control installation.

. . . true purge rate indication
. . . easily and neatly panel mounted singly or in multiple, requires a minimum of space.
. . . furnished with or without needle control valve.

$9.00 per unit, without control valve (lower price when purchased in quantity).

Write for catalog 31

NEW FLOW SWITCH PROTECTS VALUABLE EQUIPMENT



The Ratosight-Alarm provides continual visual indication of flow rate and responds instantaneously to flow rate changes only. A magnetic extension on the "metering-float" trips external switches to operate the alarm circuit. The alarm flow point is adjustable over the entire flow range and operates accurately at the set position. Built in sizes up to 1½" and stocked in cast iron and brass.

PRICES NOW REDUCED BELOW WAR-TIME PRICES

Write for catalog 92.

FLOWRATOR
TRADEMARK
FISCHER & PORTER CO.
DEPT. 7P-5C HATBORO, PENNA.

Manufacturers' New Literature

In this department we report new literature pertaining to instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on page 487.

O-205 **Bin Level Indicator.** 6-page 4" × 9" Folder 788 pictures and describes the "Bin-Eye," a diaphragm-operated mercury switch for indicating or controlling the level of materials in bins. Jeffrey Mfg. Co., Columbus 16, Ohio.

O-206 **Recording Galvanometers.** 7-page 8½" × 11" Bulletin 7-100 describes and gives technical information on maker's "Type 7-100, 7-200 Series" recording galvanometers. Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif.

O-207 **Pipe Locator.** 2-page 8½" × 11" bulletin pictures and describes the "Globe Radio Type Pipe Finder" for locating piping underground, in walls, under flooring, etc. Globe Phone Mfg. Corp., Reading, Mass.

O-208 **Photoelectric Colorimeter.** 8-page 8½" × 11" Bulletin No. 500 pictures and describes the "Hellige-Diller" photoelectric colorimeter. Hellige, Inc., 3718 Northern Blvd., Long Island City 1, N. Y.

O-209 **Low-frequency "Q" Indicator.** 4-page 8½" × 11" bulletin pictures and describes "Type 1030" low-frequency "Q" indicator which measures directly the "Q" factor of coils. Freed Transformer Co., Inc., 72 Spring St., New York 12, N. Y.

O-210 **Transmitting Components.** 12-page 8½" × 11" Catalog No. 969 pictures and describes maker's line of radio and electronic components including capacitors, inductors, insulators, couplings, etc. E. F. Johnson Co., Waseca, Minn.

O-211 **Bin Level Indicator.** 4-page 8½" × 11" bulletin with inserts pictures and describes the "Bin-Dicator" bin level indicator for use with all bulk materials. Includes diagrams showing application to signaling or control systems. The Bin-Dicator Co., Detroit 15, Mich.

O-212 **Automatic Temperature Control Systems.** 20-page 8½" × 11" Educational Bulletin No. 5 consists of charts, tables and diagrams which explain measurement and automatic control and the selection of proper control systems for process applications. Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.

O-213 **Tube Testers.** 4-page 8½" × 11" bulletin pictures and describes "Type 139" counter tube tester and "Type 140" portable tube tester. Sylvania Electric, Distributor Sales, Emporium, Pa.

O-214 **Pneumatic Control Valves.** 36-page 8½" × 11" Bulletin 277-1 pictures and describes "Stabilflo" line of pneumatic control valves and controller accessories. Appendix contains information on computing valve sizes. The Foxboro Co., Foxboro, Mass.

O-215 **Vacuum-tube Voltmeter.** 2-page 8½" × 11" Bulletin GEA-4574 pictures and describes maker's a-c. vacuum-tube voltmeter. General Electric Co., Apparatus Dept., Schenectady, N. Y.

O-216 **Moisture Meter for Concrete Sand.** 2-page 8½" ×11" bulletin pictures and describes maker's moisture meter for indicating directly the percent of free moisture in concrete sand. J. Thomas Rhamstine, Harlingen, Tex.

O-217 **Electrical Measuring Apparatus.** 8-page 8½" × 11" Bulletin G-1 pictures and describes maker's line of electrical measuring instruments and components including resistance standards, d-c bridges, decade resistance boxes, bridge components, etc. Shallcross Mfg. Co., Collingdale, Pa.

O-218 **Power Rheostats.** 4-page 8½" × 11" Bulletin E-1 pictures and describes "IRC Type PRT (AN 3155)" power rheostats. Includes temperature-rise curves. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

O-219 **"Uses Unlimited."** 2-page 8½" × 11" Vol. 2 No. 4 of this house organ pictures and describes the new "V3-14" low-torque "Micro Switch." Micro Switch, Freeport, Ill.

O-220 **Draft Gage.** 4-page 8½" × 11" Bulletin 24-B pictures and describes the "Straight-Line Diafram Gage" for measuring draft in stationary or marine installations. Ellison Draft Gage Co., 21[illegible] W. Kinzie St., Chicago, Ill.

O-221 **Dead Weight Testing Instruments.** 6-page 4" × 9" folder pictures and describes maker's line of dead weight gage testers and accessories. The Refinery Supply Co., 621 E. 4th St., Tulsa 3, Okla.

O-222 **Temperature Control Instruments for Electroplating.** 16-page 8½" × 11" Bulletin 98166 describes the application of maker's temperature control instruments to electroplating. Includes diagrams of typical installations. Taylor Instrument Companies, Rochester 1, N. Y.

O-223 **Multi-layer Interference Films.** 2-page 8½" × 11" Bulletin MI-318 describes maker's multi-layer interference films for dichroic and achromatic beam splitters. Fish-Schurman Corp., 230 E. 45th St., New York 17, N. Y.

O-224 **Concentric-scale Instruments.** 12-page 8½" × 11" Bulletin GEA-3432B pictures and describes makers line of electrical indicating instruments with concentric scales. General Electric Co., Schenectady, N. Y.

O-225 **Constant-voltage Transformers.** 32-page 8½" × 11" Bulletin CV-102 pictures and describes maker's line of constant-voltage transformers. Includes charts and curves of performance characteristics. Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.

O-226 **Remote-positioning Control.** 4-page 8½" × 11" bulletin pictures and describes "Electrol" electrical remote-positioning control system. Yardeny Engineering Co., 105 Chambers St., New York 7, N. Y.

O-227 **Vitreous-enameled Rheostats.** 4-page 4" × 8¼" bulletin pictures and describes maker's line of vitreous-enameled round rheostats in 7 sizes from 50 to 500

THERMOCOUPLE vacuum gage

COMPACT
PORTABLE
ACCURATE

This General Electric instrument is designed to provide a simple, rapid, accurate means of maintaining better control of your vacuum systems. Suited for the measurement of pressures in many manufacturing and chemical processes, and for checking evacuated systems in which a moderately high vacuum must be maintained, it permits the use of a single indicating instrument in conjunction with a number of thermocouples installed at various points in the system. In high-vacuum systems, it is valuable as a means of indicating when the pressure has been reduced to a level such that power may safely be applied to the filament of the ionization gage used for high-vacuum measurement.

MEASURES PRESSURES BETWEEN ZERO AND ONE HUNDRED MICRONS

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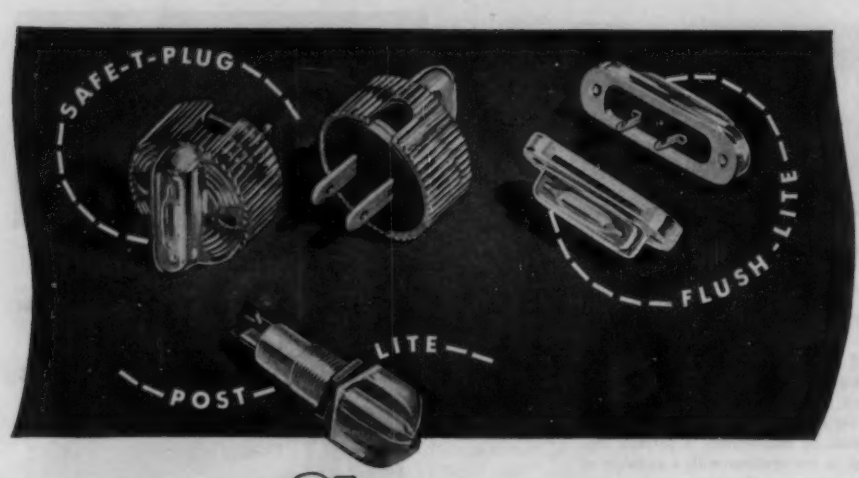

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O-228 **Decade Scaling Unit.** 2-page 8½"×11" Page 169 of Electronic Measuring Equipment Catalog pictures and describes "Type YYZ-1" decade scaling unit for nuclear research, radioactivity studies, mass spectrography, etc. General Electric Co., Electronics Dept., Syracuse, N. Y.

O-229 **"Wheelco Comments."** 4-page 8½"×11" Vol. 6 No. 2 of this house organ contains an article, "Electronic Temperature Control of Die-casting Equipment." Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.

O-230 **Water Temperature Control Instruments.** 16-page 8½"×11" Condensed Catalog 3035 pictures and describes maker's line of instruments for water temperature control. Powers Regulator Co., 2720 Greenview Ave., Chicago 14, Ill.

O-231 **Pneumatic Valves and Cylinders.** 52-page 8½"×11" Bulletin 57-A pictures and describes maker's line of pneumatic and hydraulic cylinders, and manual and electrically-operated valves. Hannifin Mfg. Co., 621 S. Kolmar Ave., Chicago 24, Ill.

O-232 **Thermocouple Lead Wire.** 4-page 8½" × 11" Bulletin 30 pictures and describes, in table form, maker's line of thermocouple lead wires for pyrometers and thermocouples. Thermo Electric Co., Fair Lawn, N. J.

O-233 **Co-axial Connectors.** 4-page 8½" × 11" bulletin pictures and describes maker's line of co-axial connectors and co-axial-type low-pass filters. Diamond Instrument Co., 7 North Ave., Wakefield, Mass.

O-234 **Midget Resistors.** 8-page 8½" × 11" bulletin pictures and describes "Microtorque Potentiometers" for proportional control. Autoflight Instruments, 285 W. Colorado St., Pasadena 1, Calif.

O-235 **"Electronics in Automatic Chemical Feed Systems."** 16-page 6" × 9" Technical Paper No. 54 is a reprint of an article of the above title by Robert T. Sheen in *Transactions American Institute of Chemical Engineers.* Milton Roy Co., 133 E. Mermaid Ave., Philadelphia 18, Pa.

O-236 **Industrial Gages and Thermometers.** 20-page 4" × 9" bulletin pictures and describes maker's line of industrial gages, including pressure, vacuum, compound, altitude, hydraulic, ammonia, and diaphragm; also shows dial thermometers. James P. Marsh Corp., 2073 Southport Ave., Chicago 14, Ill.

O-237 **Vacuum Pump.** 6-page 4" × 9" folder pictures and describes maker's pump which can be used for vacuum or air blast. Eberbach & Son Co., Ann Arbor, Mich.

O-238 **Aircraft Receiver.** 6-page 8½" × 11" bulletin pictures and describes maker's "RA-10 Series" communication receiver for aircraft. Bendix Radio Div. of Bendix Aviation Corp., Baltimore 4, Md.

O-239 **Power Supply.** 2-page 8½" × 11" Bulletin Form 210 pictures and describes "Model 210" twin power supply for laboratories, etc. Furst Electronics, 800 W. North Ave., Chicago 22, Ill.

O-240 **Electrical Gaging Instruments.** 8-page 8½" × 11" Catalog G-1 pictures and describes maker's electrical strain-gaging equipment. Statham Laboratories, 8222 Beverly Blvd., Los Angeles 36, Calif.

O-241 **Stop Watches.** 4-page 8½" × 11" bulletin pictures and describes "Lemania" line of stop watches and chronographs. Bernard S. Lippman Co., 630 5th Ave., New York 20, N. Y.

O-242 **Vibrometer.** 4-page 8½" × 11" Bulletin No. 33 pictures and describes "Model 11-B" vibrometer for measuring vibration electronically. Televiso Prod-

...s Co., 7466 W. Irving Park Rd., Chi-...go 34, Ill.

...0-243 **60-cycle Filter.** Single sheet 8½" ... 11" pictures and describes "Model 1050" ...-cycle filter for use in calibration of ...truments and measurement of harmo... distortion of amplifiers, transformers ... tubes. Freed Transformer Co., 72 ...ring St., New York 12, N. Y.

...0-244 **Voltage Regulators.** 16-page 8½" ... 11" Catalog S2-47 pictures and de...ribes maker's line of voltage regulators ... "Nobatron" power supplies. Sorensen ... Co., Inc., 375 Fairfield Ave., Stamford, ...nn.

...0-245 **Pyrometers.** 16-page 8½" × 11" ...lletin 4361 pictures and describes mak...'s line of pyrometers in several types ... sizes. Illinois Testing Laboratories, ...c., 420 N. LaSalle St., Chicago 10, Ill.

...0-246 **Stiffness Gage.** 6-page 8½" × 11" ...lletin 4506 pictures and describes the ...-5" stiffness gage for determining both ... initial and normal stiffness of sheet ... wire specimens. Taber Instrument ...rp., North Tonawanda, N. Y.

...0-247 **"General Radio Experimenter."** ...page 6" × 9" Vol. 21 No. 9 of this house ...an is devoted to a description of "Type ...75-A" frequency monitor. Includes cir...it diagram and input sensitivity curves. ...eneral Radio Co., 275 Massachusetts ...ve., Cambridge 39, Mass.

...0-248 **"Ohmite News."** 2-page 8½" × ... 11" February 1947 issue of this house or...an includes an article, "Wattage and ...rrent Relation in Resistors," which ...iscusses the selection of resistors for ...ecific applications. Ohmite Mfg. Co., ...35 Flournoy St., Chicago 44, Ill.

...0-249 **Cycle Counter.** 4-page 8½" × 11" ...lletin No. 139 pictures and describes ..."Model AC-1" portable cycle counter for ...ting high-speed relays, welding timers

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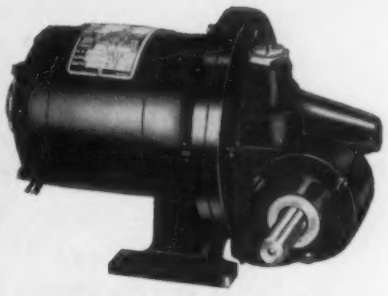

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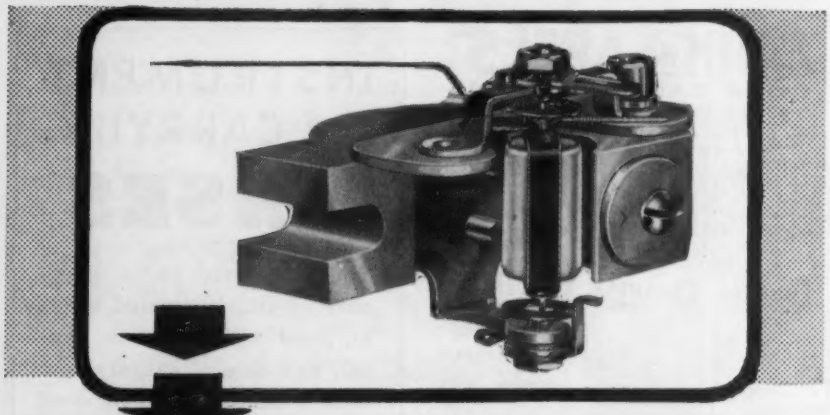

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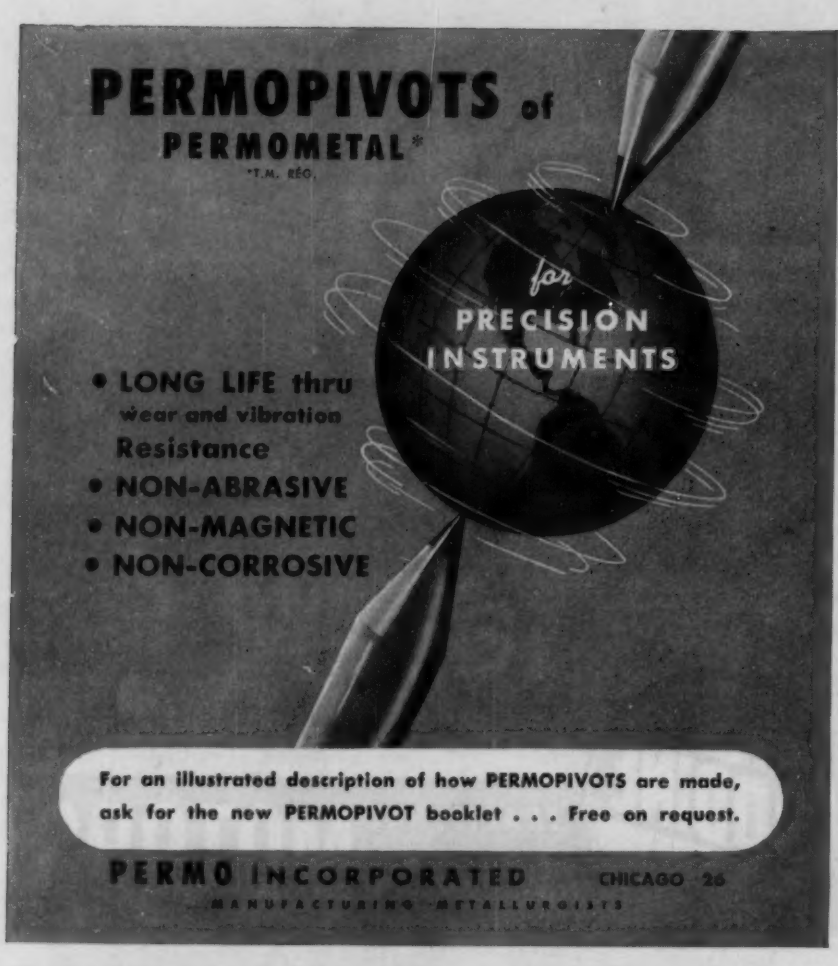

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O-250 **"The Gotham Bulletin."** 4-page 8½" × 11" Vol. 1 No. 2 of this house organ contains condensed descriptions of a number of the maker's controllers. Gotham Instrument Co., Inc., 149 Wooster St., New York 12, N. Y.

O-251 **Optical Benches.** 24-page 8½" × 11" Bulletin 156-74 pictures and describes maker's line of optical benches in single-rod, double-rod and lathe-bed types. Also lists optical bench parts and accessories. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

O-252 **Vacuum Thermocouples.** 6-page 4" × 9" Bulletin V22 pictures and describes maker's vacuum thermocouples for measuring small high-frequency currents and voltages. Field Electrical Instrument Co., 109 E. 184th St., New York 53, N. Y.

O-253 **Induction Soldering Unit.** 4-page 8½" × 11" bulletin pictures and describes maker's portable bench-type induction soldering unit. Marion Electrical Instrument Co., Manchester, N. H.

O-254 **Synchronous Motor.** 2-page 8½" × 11" bulletin pictures and describes "Model 805" fractional-horsepower motor said to maintain constant synchronous speed regardless of load and voltage changes. Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

O-255 **Coating Thickness Gage.** 8-page 8½" × 11" Bulletin 2125 pictures and describes the "Aminco-Brenner Magne-Gage" for measuring non-destructively the local thickness of coatings on metals. American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.

O-256 **"Faxfilm Fax."** 2-page 8½" × 11" Vol. 1 No. 3 of this house organ contains a number of short articles on the use of the "Faxfilm" replica method of surface measurement. The Faxfilm Co., 1220 W. 6th St., Cleveland 13, Ohio.

O-257 **Resistors.** 4-page 8½" × 11" bulletin pictures and describes 19 types of inductive and non-inductive resistors. Includes sample. Precision Resistor Co., 330 Badger Ave., Newark 3, N. J.

O-258 **Feed Water Control Data.** 16-page 8½" × 11" Bulletin 105-B contains performance data on maker's three-element air-operated feed water control system. Includes diagrammatic layout of system and reproductions of charts from systems in use. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

O-259 **"Uses Unlimited."** 2-page 8½" × 11" Vol. 3 No. 1 of this house organ contains an article on the V-2 rocket entitled, "Practical Value of High Altitude Explorations." Micro Switch, Freeport, Ill.

O-260 **Perspective Drawing Instrument.** 8-page 8½" × 11" Folder Form PS-47 pictures and describes maker's "Stereograph" perspective drawing instrument. Pomeroy Stereograph Co., Inc., Ferguson Bldg., Cleveland 14, Ohio.

O-261 **"Modern Precision."** 8-page 10½" × 15½" Vol. 6 No. 3 of this house organ contains a number of short articles on applications of maker's instruments to industrial control problems. Leeds & Northrup Co., 4908 Stenton Ave., Philadelphia 44, Pa.

O-262 **Pressure Controllers.** 20-page 8½" × 11" Bulletin 462 pictures and describes maker's line of external-pilot-operated pressure controllers. Leslie Co., 225 Delafield Ave., Lyndhurst, N. J.

O-263 **"Weston Engineering Notes."** 8-page 8½" × 11" Vol. 2 No. 1 of this house organ contains an article entitled "Modern Thermometry" by A. H. Lamb, which discusses the development and use of the bimetal thermometer. Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

O-264 **Height Gage.** 4-page 8½" × 11"

Circular No. 486 pictures and describes the "Electrolimit" height gage for use in inspection rooms, tool rooms and in the shop. Pratt & Whitney Div., West Hartford 1, Conn.

O-265 **Illuminated Magnifiers.** Single sheet 8½" × 11" pictures and describes the "C-Master" illuminated magnifier with 4½" double convex lens. Ullman Products Corp., 857 4th Ave., Brooklyn 32, N. Y.

O-266 **Timing Motor.** 4-page 8½" × 11" Bulletin No. 10 pictures and describes "Type SX" self-starting synchronous timing motors with speeds from 1 rev./sec. to 1 rev./24hr. R. W. Cramer Co., Inc., Centerbrook, Conn.

O-267 **High Vacuum Equipment.** 8-page 8½" × 11" Addition to H-v. Equip. Catalog pictures and describes "Type VMF-100" fractionating pump and a Knudsen vacuum gage. Distillation Products, Inc., 755 Ridge Rd. W., Rochester 13, N. Y.

O-268 **Specific Gravity Indicator.** 2-page 8½" × 11" Catalog Section 91-B pictures and describes maker's compact continuous specific gravity testers for continuous indication of fluid specific gravity in closed piping systems. Fischer & Porter Co., Dept. 9D-B, Hatboro, Pa.

O-269 **Boiler Water Level Control.** 8-page 8½" × 11" Bulletin No. 465 is a case history of boiler water level control at West Reading Station of Metropolitan Edison Co. using maker's equipment. Northern Equipment Co., Erie, Pa.

O-270 **Pneumatic Transmission System.** 4-page 8½" × 11" Catalog No. 5902 pictures and describes the "New-Matic" remote transmission systems for applications where electrical transmission for indicating, recording and control of temperature, pressure, flow and liquid level is neither desirable nor permissible. Contains several schematic diagrams of typical applications. Brown Instrument Co., Wayne & Roberts Aves., Philadelphia 44, Pa.

O-271 **Polymeter.** 4-page 8½" × 11" Bulletin pictures and describes the "Type 734" polymeter, said to combine the advantages of the vacuum-tube voltmeter with wide-range measurement of resistance and current. Sylvania Electric, Distributor Sales, Emporium, Pa.

O-272 **Liquid Level Controllers.** 28-page 8½" × 11" Catalog 147 pictures and describes maker's all-electric floatless liquid level controllers. Describes principles of operation and gives application diagrams. B/W Controller Corp., 2200 E. Maple Rd., Birmingham, Mich.

O-273 **"The Laboratory."** 32-page 6" × 9" Vol. 16 No. 5 of this house organ contains an article entitled "Recent Advances in Fluorine Chemistry," descriptions of new laboratory instruments, and a table of laboratory conversion factors. Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

O-274 **Conductivity Apparatus for Boiler Water and Condensate.** 4-page 8½" × 11" Bulletin RD-104 pictures and describes the "Solu-Bridge" conductivity apparatus for determining carry-over in steam, purity of distilled water, leakage of contaminating liquids into condensate, and boiler water concentration. Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J.

O-275 **Electronic Equipment.** 100-page 8" × 9" 1947 Catalog pictures and describes electronic equipment and components for industrial and communications use. Walker-Jimieson, Inc., 311 S. Western Ave., Chicago 12, Ill.

O-276 **Boiler Water Level Controllers.** 4-page 8½" × 11" Bulletin 147 pictures and describes maker's boiler water level controllers, including standard multi-stage controllers, combination water column and controller, and single-stage control. Magnetrol, Inc., 2110 S. Marshall Blvd., Chicago 23, Ill.

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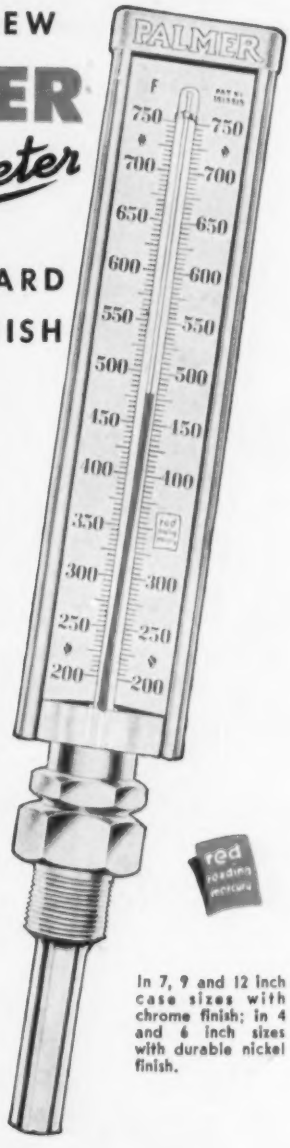

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O-277 **Venturi Tubes.** 4-page 8½" × 11" Bulletin No. 450 pictures and describes "Type TG" insert venturi tubes and nozzles. Simplex Valve & Meter Co., 6742 Upland St., Philadelphia, Pa.

O-278 **Connectors.** 76-page 8½" × 11" catalog pictures and describes maker's line of electrical multi-pole connectors. Describes numerous applications of the various types. Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 13, Calif.

O-279 **Vacuum-tube Voltmeter.** 4-page 8½" × 11" Bulletin No. 32 pictures and describes "Series 200A" vacuum-tube voltmeter. Televiso Products Co., 7466 W. Irving Park Rd., Chicago 34, Ill.

O-280 **Surface-temperature Pyrometer.** 12-page 8½" × 11" Bulletin No. 4257 pictures and describes the "Alnor Pyrocon," a hand-held portable pyrometer for temperature readings of flat or curved, moving or stationary surfaces. Illinois Testing Laboratories, Inc., 420 N. LaSalle St., Chicago 10, Ill.

O-281 **"Wheelco Comments."** 4-page 8½" × 11" Vol. 6 No. 3 of this house organ contains several articles on the application of the maker's products to industry, including one entitled, "Trend to Gas or Oil Burning with Combustion Safeguards," which concludes that the economic situation nullifies coal price differentials. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.

O-282 **Resistance Bridge.** 4-page 8½" × 11" addition to Electronic Measuring Equipment Catalog pictures and describes "Model YMW-1A Unimeter" and "Model YCW-1" capacitance resistance bridge. General Electric Co., Electronics Dept., Syracuse, N. Y.

O-283 **Universal Testing Machine.** 4-page 8½" × 11" Bulletin 182 pictures and describes "Model S-10" universal hydraulic testing machine in three models with capacities of 4,000, 10,000 and 20,000 pounds. Baldwin Locomotive Works, Eddystone Div., Philadelphia 42, Pa.

O-284 **Mechanical Pressure Gage.** 2-page 8½" × 11" bulletin pictures and describes maker's mechanical pressure gage for indicating pressures in mechanical assemblies. W. C. Dillon & Co., Inc., 5410 W. Harrison St., Chicago 44, Ill.

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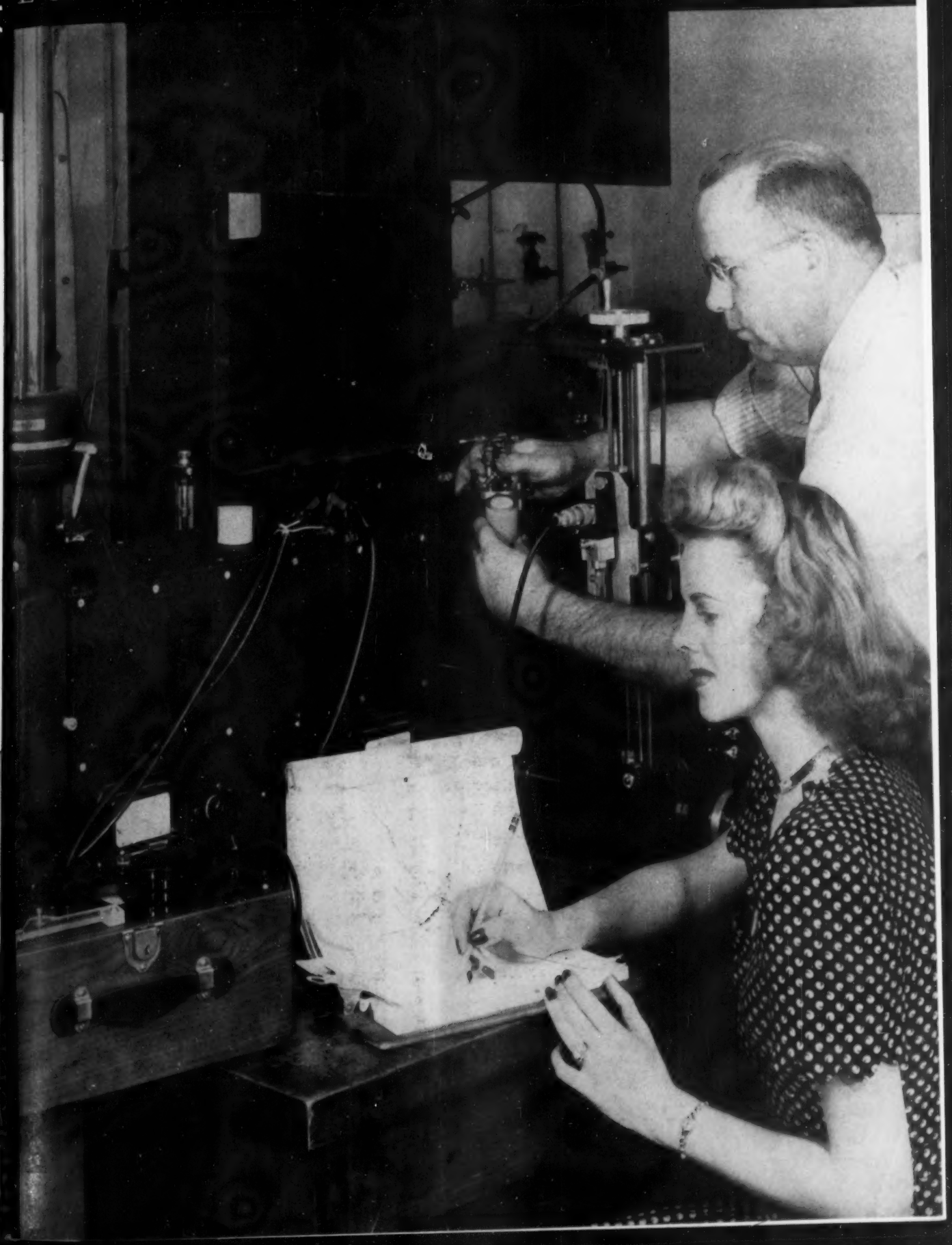
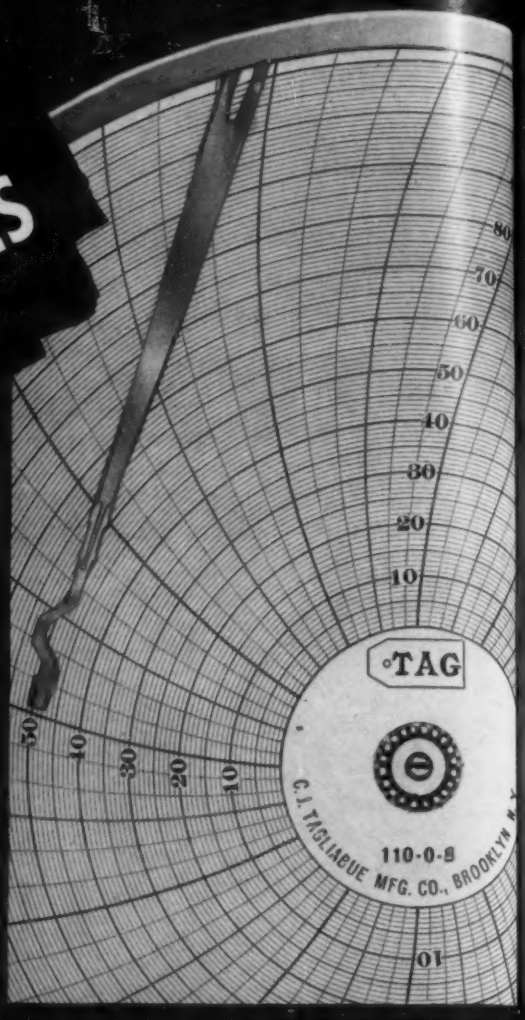


Know YOUR TEMPERATURES



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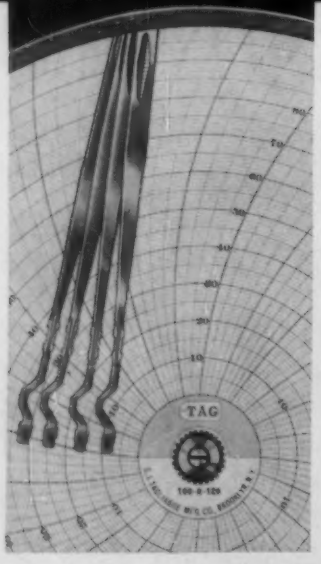

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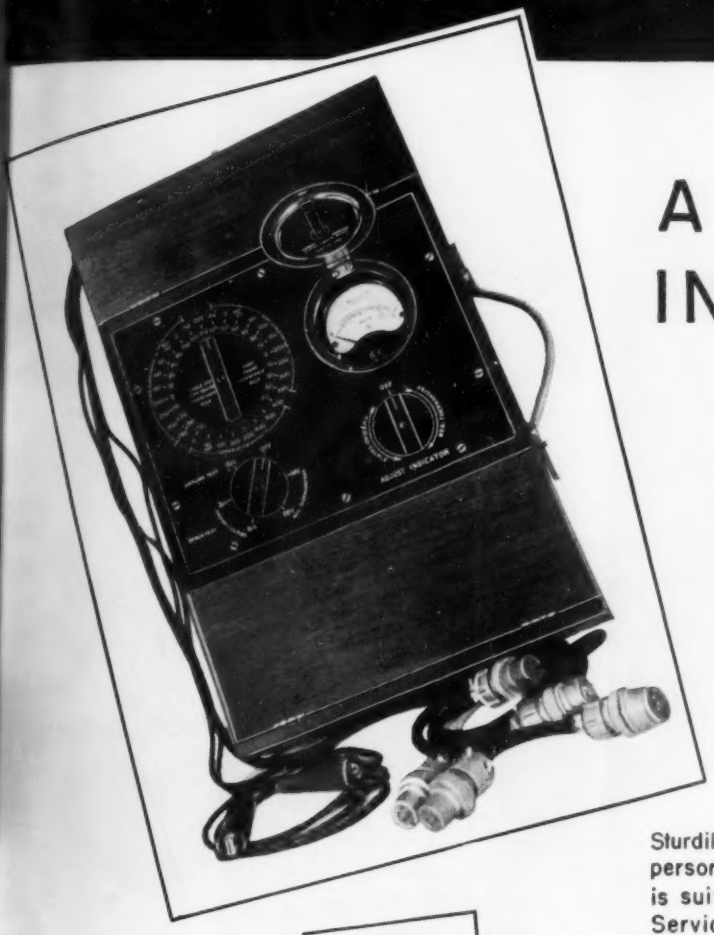

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INSTRUMENTS ON THE MARCH

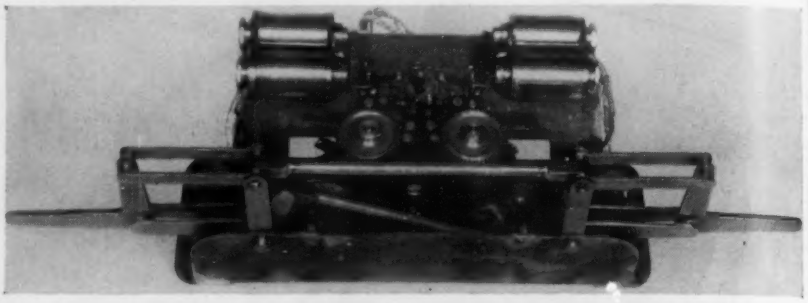
Guided Missiles Are "Instrument-flying" Missiles

WASHINGTON, D. C.—The "Bat," first fully-automatic guided missile successfully used in combat by any nation, is one of several guided missiles developed by the National Bureau of Standards under the sponsorship of the Navy Bureau of Ordnance. Work on guided missiles constituted one of the major war activities of the NBS. The "Robin," the "Pelican" and the "Bat" were brought to a state of completed development. Because of the much greater operational flexibility of the "Bat," however, it was the only one carried into large-scale production and combat use. The program on guided missiles began in the fall of 1940, when the NDRC requested the Bureau to permit the appointment of Dr. Hugh L. Dryden as aerodynamics consultant in connection with a contract for development of a glide bomb capable of being directed to the target by radio remote control utilizing television sighting.

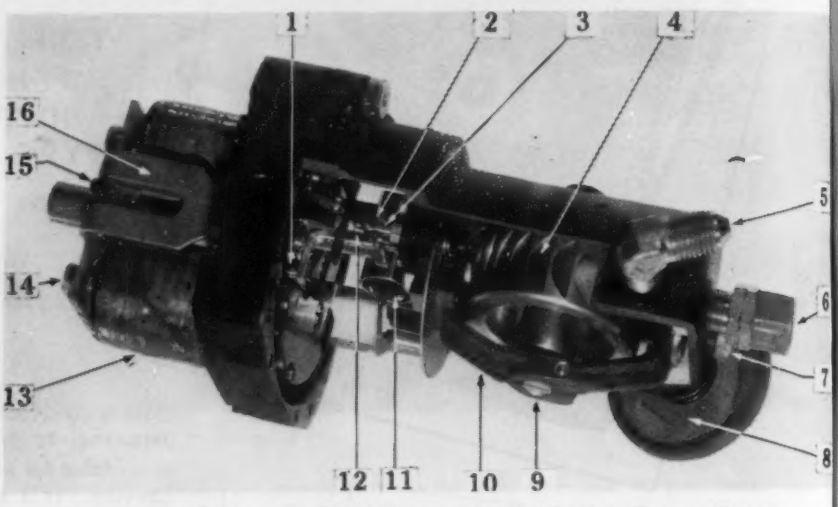
Designed to glide silently at the speed of a fighter plane, with a 1000-pound bomb as cargo, the "Bat" is carried under the wing or fuselage of a Navy fighter or bomber and may be released at a distance as great as 14 miles from the target. Once the crew of the mother plane has located a ship or other target, the missile is set for this particular target and the release button is pushed. From then on the "Bat" automatically follows every maneuver of the target until it eventually strikes home, while the mother plane is free to proceed as its pilot wishes.

In normal use the target is first located by the standard search radar of the mother plane. The plane is then headed toward the target, and the radar transmitter and receiver in the "Bat" are aimed in its direction. Target data from the radar in the missile are displayed on a separate indicator in the mother plane under the control of the operator. After the radar equipment is manually adjusted to the proper conditions, it is switched to automatic tracking, and the missile is released. Echoes from the target are continuously detected by the radar receiver in the missile, and the output supplies correction signals to the flight control units to direct the missile toward the target.

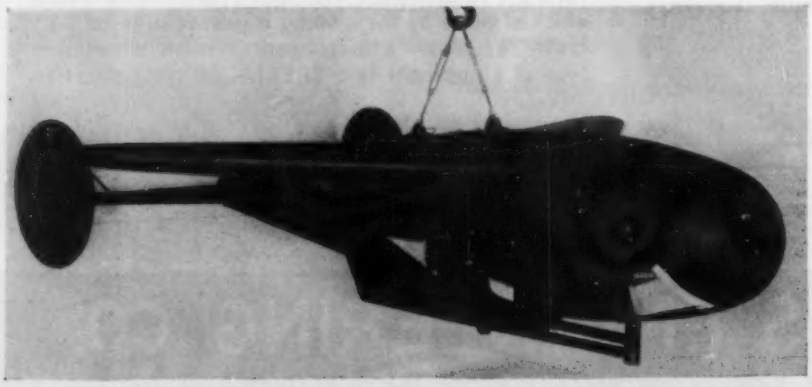
The outstanding features of the "Bat" as a combat weapon are (1)



An early model of the servo unit used in the "Bat" to move the control surfaces.



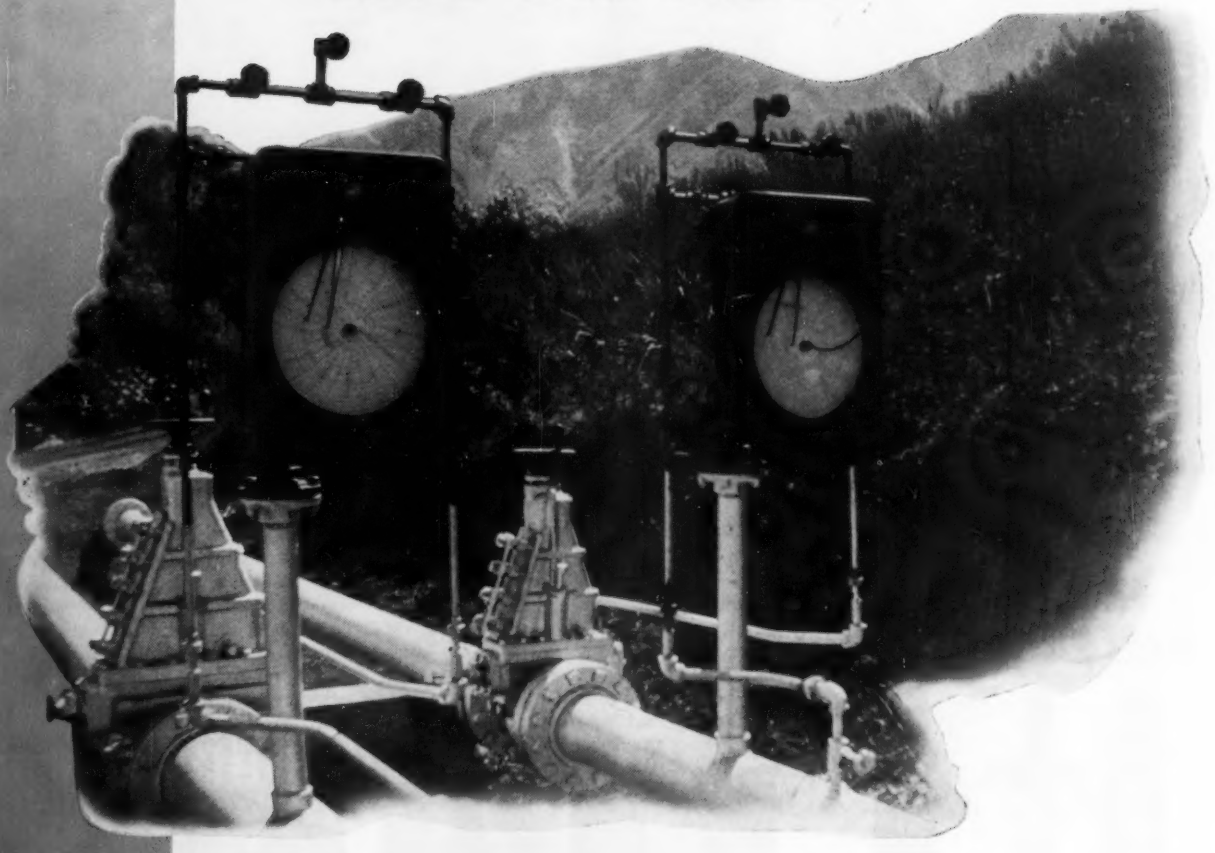
Cutaway view of the gyroscopic stabilizer used in the "Bat." 1. Contact adjustment; 2. Centering spring; 3. Contact arm; 4. Gyro wheel; 5. Air outlet; 6. Regulator; 7. Gimbal pivot; 8. Air intake filter; 9. Gyro wheel axle bearing; 10. Gimbal frame; 11. Damping piston: 12. Contact; 13. Biasing electromagnet; 14. Biasing adjustment; 15. Lever pivot; 16. Biasing lever.

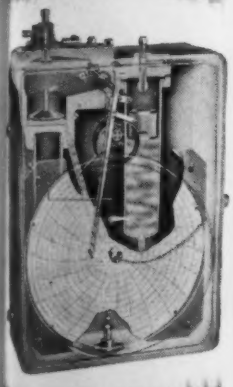


The "Pelican." Note the instrumentation for flight tests. Directly beneath the wing is a 16-mm. Bell and Howell, Type M-4A, gun-sight aiming-point camera. Slightly forward and lower is mounted a 16-mm, Cine Kodak Model E camera. The housing on the nose covers a panel of signal lamps indicating radar controls being applied. The cameras simultaneously photograph the panel and the ground ahead of the glider.

"Bat" shown mounted under the wing of a Navy patrol bomber. Flight characteristics of the carrying plane are only slightly affected by the missile, while flight operations are not in any way altered.

Where Low-Cost Accuracy Saves Time and Labor





OUT IN THE FIELD, where maintenance is infrequent and tough conditions call for dependable measurement, you'll find that METRIC American Orifice Meters pay off in low-cost accuracy.

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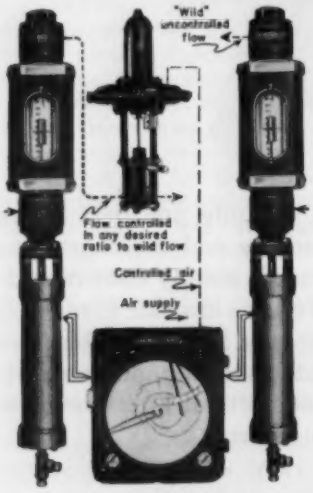

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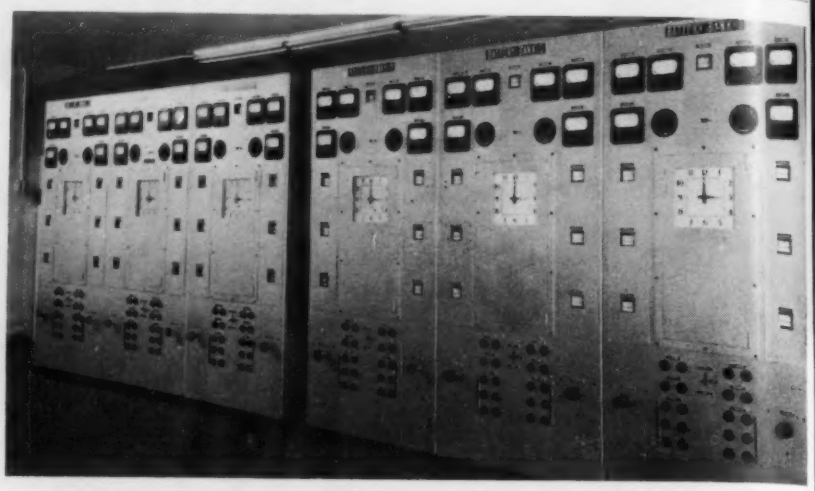


Fig. 1. Front view of the control cabinets for the six cycling units. On each cabinet are the follower clock, and the voltmeters, ammeters, cycle counters and ampere-hour meters (along the top and sides). In the center of each cabinet is the program-controller panel.

Cycle-testing Laboratory for Aircraft Batteries

WASHINGTON, D. C.—A new laboratory for battery research has been constructed at the National Bureau of Standards with the coöperation of the Bureau of Aeronautics, Navy Department. Equipped with completely automatic controls for cycling batteries, this laboratory offers a unique method of testing batteries under conditions simulating those met in practice.

The equipment provides for discharging the batteries through constant resistance and recharging them either at constant potential or at constant current, as desired. The cycling may be performed automatically for batteries under conditions of room temperature, extreme heat, sub-zero temperatures, and "flight" vibration.

Six similar cycling units have been

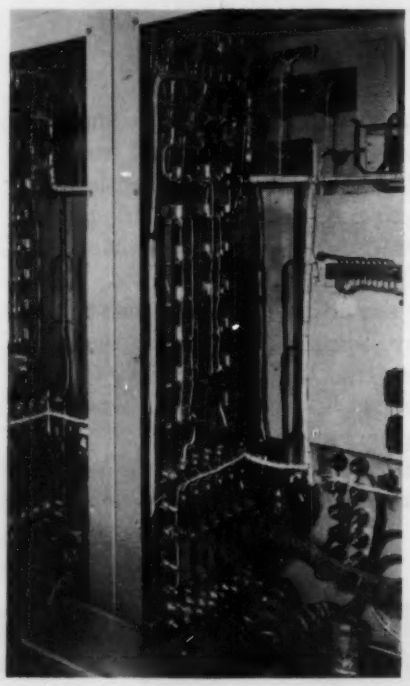


Fig. 2. Back view of part of the control cabinets for the six cycling units. On the inside of each cabinet are the sequence relays mounted in two horizontal rows near the top, the contactors in the middle, and the shunts in two horizontal rows near the bottom of the wall.

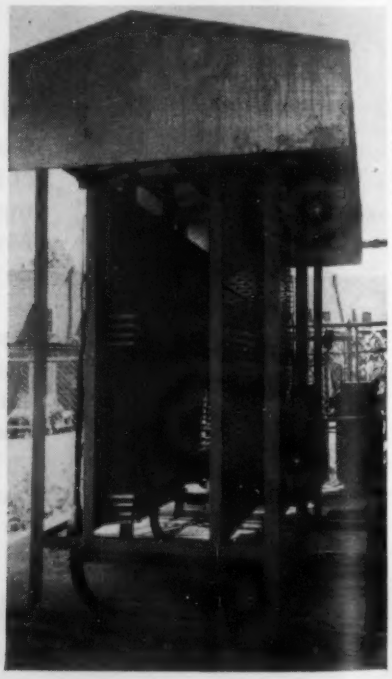
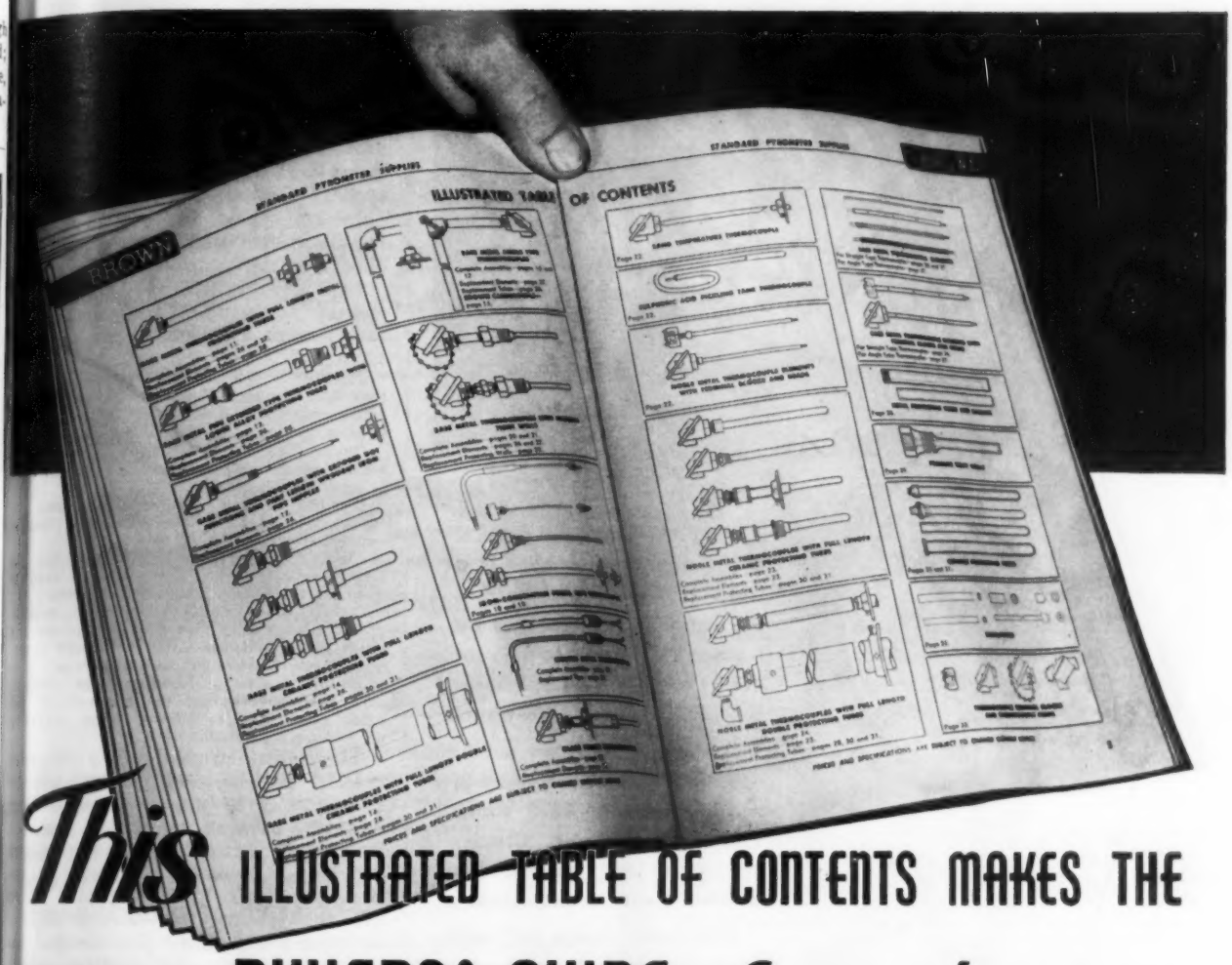


Fig. 3. Out-of-doors load resistor (with the housing removed). Natural circulation cools the resistors, which utilize Nichrome ribbon wire for high rates of discharge and helical coils of Nichrome wire for intermediate and low rates of discharge and for charging at constant current.



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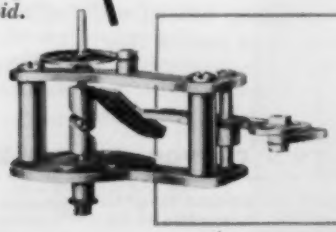

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installed, each operated independently by a master electric clock. Each unit consists essentially of a control cabinet, two motor-generator sets, and the necessary resistors. From one to six 24-volt batteries may be cycled on each unit. Each control cabinet contains a program machine for automatic cycling, sequence relays, contactors (aircraft type), and a copper oxide rectifier which supplies 24-volt d.c. for operating the switching devices.

Each program machine carries three endless tapes which pass under contact fingers and control six program circuits:

Circuit 1. (a) Starts motor-generator sets and connects batteries in parallel for constant potential charge. (b) Stops motor-generator sets and disconnects batteries.

Circuit 2. (a) Connects batteries in series on constant current charge. (b) Disconnects batteries.

Circuit 3. (a) Connects batteries in series on high-rate discharge. (b) Disconnects batteries.

Circuit 4. (a) Connects batteries in series on intermediate rate or low rate discharge. (b) Disconnects batteries.

Circuit 5. (a) Short-circuits a portion of the charging resistor for constant current charging at normal rate. (b) Opens short-circuit on resistor for finishing rate.

Circuit 6. (a) Operates cycle counter. (b) Disconnects one motor-generator set after peak load is passed when charging at constant potential.

The control circuits in any program machine can be used independently or concurrently in any order depending upon the program which has been set up. Toggle switches in the machine provide for switching to manual operation when desired, and skip pins which lift the contact fingers provide for omitting the program for specified intervals of time. Interlocking relays prevent the connection of batteries in series and parallel at the same time or in the event of an error in manual switching or a failure of a sequence relay.

The general plan of the laboratory was developed by C. L. Snyder, National Bureau of Standards, with the cooperation of Lt. Kenneth Dawkins of the Bureau of Aeronautics. Engineers of the Standard Electric Time Company worked out the details for the automatic controls and constructed the control cabinets.

Pocket-size Adhesion Tester

NEW YORK CITY.—Most instruments designed to measure adhesion of organic coatings are restricted to laboratory use on specimen panels. It is common practice, in production or in the field, to estimate adhesion of paint films on parts by the finger-nail or knife. To fill the need for a quantitative method embodied in a measuring instrument easily carried to the work and suitable for parts too large to handle in the laboratory, a pocket-type adhesion tester has been designed by Bell Telephone Laboratories, it was disclosed by R. J. Phair, of Bell Labs' Chemical Laboratories. Small enough to be held easily in the hand, the instrument meas-

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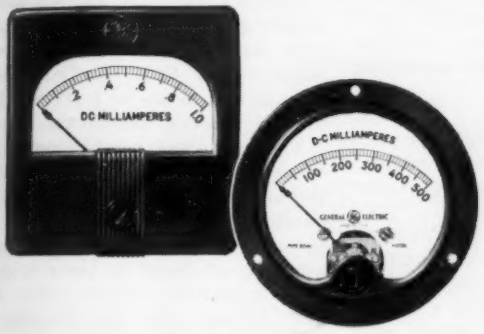

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Also, more favorable prices, made possible by new discount benefits, are now available to you when ordering these standard types and ratings.

Included in these stocks of compact, high-quality G-E instruments are ammeters, voltmeters, milliammeters, and microammeters . . . instruments for applications where AVAILABILITY counts.

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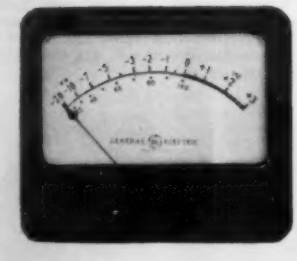
In addition, General Electric is equipped to solve your individual instrument problems. Requests are welcomed for special, made-to-order instruments to be incorporated in your product where standard models cannot be used. For further information contact your General Electric representative or write to *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*



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Illustrated literature, available on request, shows more models of copper oxide rectifiers, plus a line of selenium rectifiers and photocells. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

ures adhesion by determining the pressure that has to be applied to a scratching element to make it expose the base material under the finish. The scratching element is mounted at the end of a short cylindrical rod and is pressed by a spring against the surface tested. A threaded sleeve controls the pressure exerted by the spring by squeezing it between the end of the sleeve and a shoulder on the rod. Graduations on the outer end of the rod, which projects through the threaded sleeve, indicate the pressure applied. These parts are supported by a housing which has rollers on which the instrument rides over the surface of the finish. When both rollers are firmly pressed against a flat surface the spring pressure is transmitted directly through the scratching element to the test film.

The scratching element is a steel disk 0.256″ O.D. and 0.0625″ thick. The periphery of the disk is smoothly rounded to a radius of 0.0312″, hardened, highly-buffed and chromium-plated.

In use the instrument is set for minimum pressure, pressed firmly against the coating to be measured so that both rollers are in contact with it and then pushed with a slow, steady motion over the film. This process is repeated, with increasing pressure obtained by turning the threaded outer sleeve an arbitrary amount, until the film fails. This occurs when the film is removed by the scratching disk and the base surface is exposed. The adhesional level is then read from the scale on the upper end of the graduated rod. Each division represents about a 500-gram increment and the scale range is 500 to 5,000 grams or from poor to excellent adhesion.

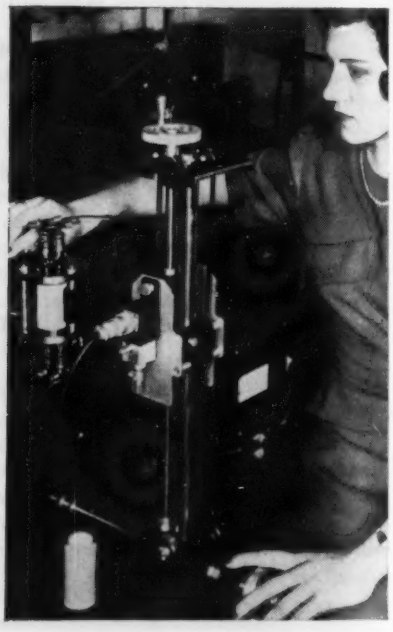
"X-raying Oil Fields" in the Laboratory

[SEE COVER PHOTO]

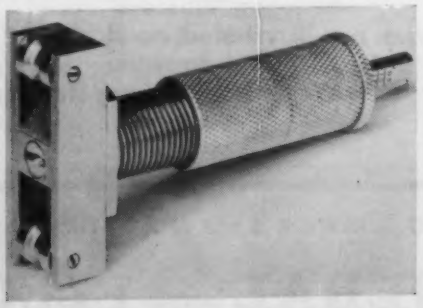
HARMARVILLE, Pa.—A method of x-raying oil fields by remote operation from its research laboratories has been developed by Gulf Oil Corp. and will soon be put to use to increase the yield of the world's petroleum reservoirs.

The new instrument method helps solve the riddle of how oil flows through the sand and rocks under any particular field, and how it is affected by underground water and gas. Since x-raying oil fields at their sites would be impractical, developers of the new method took the opposite course and brought the fields to the laboratory. Experiments were begun with

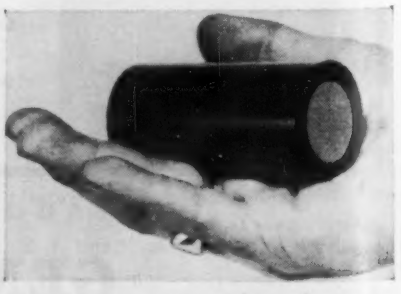
This pocket tester, shown here in a laboratory, can be used in the field, on parts too large to be brought to a laboratory.



A sample of oil-field rock being mounted in the x-ray permeability-saturation determination apparatus, where it will be injected with oil, gas and water, and then x-rayed.



Adhesion of paints and other finishes is measured with this pocket tester.



Rock sample (cast in Bakelite) brought from an oil field to be x-rayed.

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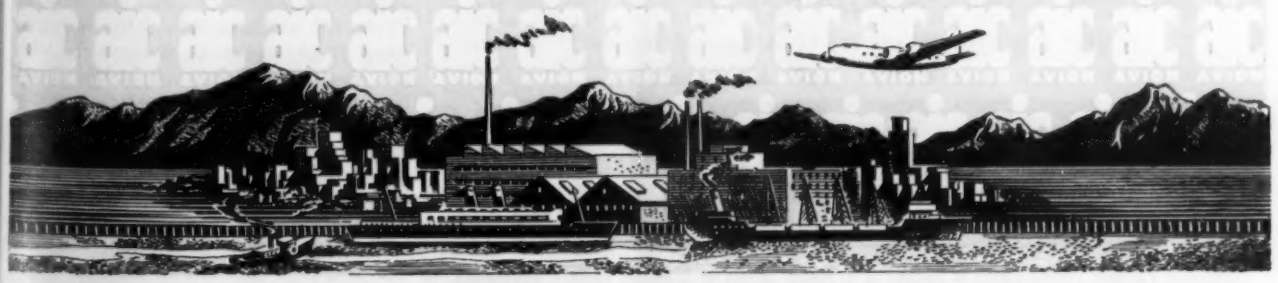

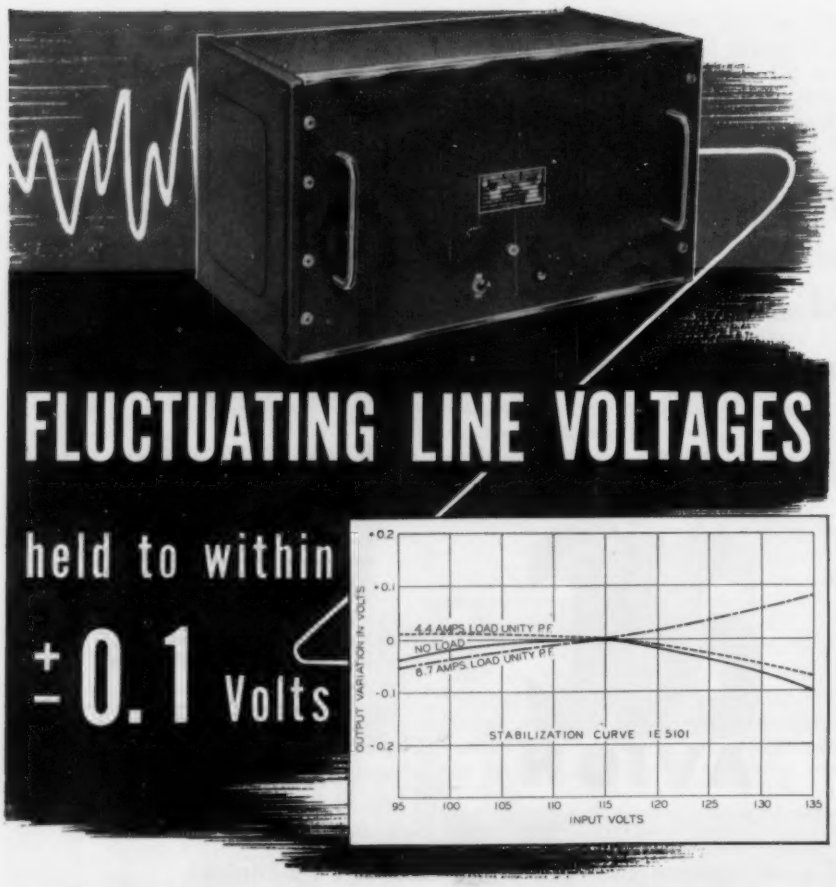

STABILINE *Instantaneous Electronic* VOLTAGE REGULATOR

With a STABILINE type IE Voltage Regulator in the power line, electrical apparatus is assured of constant voltage. Regardless of line changes — rapid fluctuations or slow variations — the delivered voltage is held to within ± 0.1 volts of the preset value. Typical are the performance curves of type IE5101. Although the input line voltage may vary from 95 to 135 volts, the preset output voltage is stabilized to well within ± 0.1 volts.

Fluctuating line voltage is just one problem of many in maintaining constant voltage. Others are varying frequencies, loads, power factors together with waveform distortion. An investigation of the STABILINE type IE will show, in addition to stabilization of ± 0.1 volts, such characteristics as . . . waveform distortion never exceeding 3 percent . . . regulation to within ± 0.15 volts for any load current change or load power factor change from lagging .5 to leading .9.

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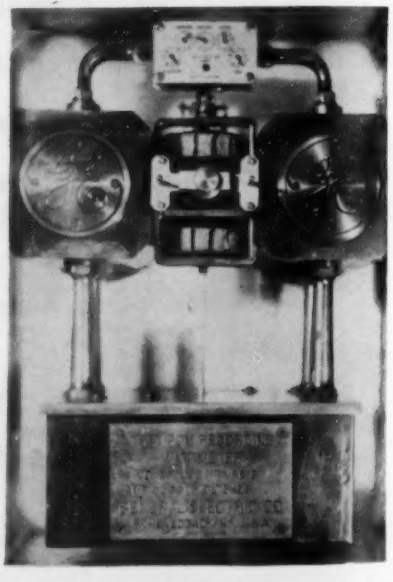
Powerstat Variable Transformers • Voltbox A C Power Supply • Stabiline Voltage Regulators.

columns of sand 10 feet high taken from the oil wells. Today a 3" x 1" core from the drill hole is subjected to artificial pressures and saturations of oil, gas, and water. The progress of these fluids in the core is measured by an x-ray instrument named Apparatus for Determining Permeability-Saturation. An opaque tracer is mixed with the liquid or gas. (This principle is similar to taking x-rays of the digestive tract after feeding with opaque barium compounds.) First step is to establish a basis for comparison by studies of the core at 100% and at zero saturation. Then flow experiments, reproducing conditions which might be created by various recovery methods are made. Effects of gravity, capillary attraction, and the amounts of oil, gas and water already in the sand are charted.

Correlation of data permits determining how natural pressure, or artificial gas injection, or water flooding, will move oil through various strata toward well shafts. Operating methods can be planned accordingly and the extent of the yield can be forecast.

Permeability-saturation determination by x-ray represents an extension of the Electrolytic Model Oil Field technique developed by Gulf Research (see *Instruments*, Oct. 1946, page 599) for predicting GENERALIZED oil field behavior and guiding placement of wells: it analyzes LOCAL flow conditions, both existing and possible, in specific fields.



FORTY YEARS YOUNG. For this G-E "Type G" watthour meter, life begins at forty. It has operated continuously without repairs for forty years at the Central Guanica, a large sugar refinery in Aguadillo, Puerto Rico. E. R. Ball, G-E Service Engineer who visited the plant recently, reports that on test it retained its original accuracy. A mechanical inspection revealed no visible wear of operating parts and none of the corrosion usually associated with the heat and high humidity of the area.

EDITORIAL By M. F. BEHAR

Automatize Quality Control!

BETTER uniformity of products, minimization of rejects and improved quality of products were listed nearly a quarter-century ago among the aims of Instrumentation.

"So what? — Everybody in industry has these aims and your so-called new science is not needed," scoffed most listeners, some of them adding that quality would be improved in the future, as it was then, with the aid of instruments in their laboratories—NOT with the aid of instruments on the processes.

"Don't enrage our skilled old operators by suggesting that automatic controllers be installed and don't spoil the new operators we're training," was a frequent parting shot by Chief Chemists, Chief Metallurgists, Chief Inspectors, and others whose duties included (unsystematically) those of the modern Director of Quality Control.

The FACT that organization charts of modern industries include a Director of Quality Control bears witness to the value of Instrumentation (the science) and of instrumentation (the devices).

Were it not for this science—organized knowledge of measurement and control laws, principles, methods and means common to ALL industries and applicable to all processes—there would be no Quality Control in the modern sense; responsibility for product quality would still fall on different specialists: here a steel metallurgist, there a soap chemist; here a rubber technologist, there a dairyman; here a ceramist, there a paper chemist; here a textile specialist, there a brewmaster; men whose only common ground would be grammar or gardening or guns or golf.

The foregoing is a strong assertion. Some subscribers may doubt it; most will accept it; a few old subscribers could prove its truth better than we could, by case histories with many statistics covering their last fifteen years' production, man-hours per unit, percents of rejects, specific improvements, etc. We shall try to prove it by a general (rather than a "case") history—not a history of the whole Instrumentation movement but only of its Quality Control aspects—not a dry history but an informal tabloid history with Instrumentation laws, principles or ideas condensed into slogans or dogmas.

1. Antecedents: "Don't Guess, Measure!" We stand on the shoulders of giants: 18th-century physicists and chemists, and 19th-century metrologists, who developed systems of weights and measures, adopted reference points, established units and created dimensional analysis. All honor to them!

2. "Conquer the Variables!" Likewise, long before this early slogan was coined, the aim it expresses was being striven for, often with more zeal than science, by pioneer users of instruments in various industries.

3. "Reduce Variables to Measurables by Isolating Them." With the enunciation of this Instrumentation principle came also the first classification of measurables into (1) processing conditions such as temperature, pressure, flow-rate, duration, etc., (2) physical and chemical properties of the product, (3) composition of the product, (4) simple magnitudes and (5) simple quantities. METHODS of measurement were likewise analyzed and two sets of classification systems established: (1) for classifying MEASURING methods; (2) for the methods of measuring each MEASURABLE. Characteristics (advantages and limitations) were tabulated, making the new science USABLE.

4. "If It's Testable It's Incontestable." The quality of a product is not measurable *per se* but its composition and properties are measurable. The correct use of the right instruments being encouraged, "quality" became definable in more fields, specifications were simplified and the design of new special testing instruments completed the happy circle.

5. "If You Can Measure It You Can Control It—or Its Effects." (last three words refer to the weather, etc.) This principle was not new as regards processing conditions: our grandfathers controlled pressures, temperatures and durations, but its universality was doubted. It seemed impracticable (except in the simplest cases) to control properties by using the readings of the property-measuring or concentration-measuring instrument to adjust the instruments which measured and controlled the processing conditions. This was about twenty years ago when laboratories made the tests and when batch processes were the rule.

6. "Measure Continuously and Make Your Processes Continuous." This idea was—and still is—one of Instrumentation's most precious gifts, for it was reinforced by classifications of primary elements, of intermediate elements, of indications, of records, of relays and of servos. This gold-mine of ideas did not neglect the useful possibilities of discontinuous methods.

7. "If You Can Control Manually You Should Control Automatically." Our grandfathers practiced this dictum in a few cases as they did No. 5. Likewise, too many engineers doubted (and still doubt) its applicability to the automatic control of properties of products except in the simplest cases. Descriptions of successful applications were widely circulated, therefore, as object lessons. Again, publicizing the possibilities of discontinuous methods aroused the interest of more industries.

8. "Modes of Control" was an expression coined just twenty years ago to classify and evaluate the many different behaviors displayed by various types of automatic controllers when controlling the numerous types AND SIZES of applications (machines, processes, etc.). Spreading the idea that an automatic controller can behave like a human being induced quality-control executives to look into subjects previously studied only by control-system inventors and builders.

9. "Design Controllability Into Processing Units." Scorned when proposed in 1930, this idea later spread at geometric expansion, to its apotheosis in Manhattan Project plant designs where quality control—purity control to unbelievably small tolerances — is automatized. It CAN be done!

10. "Time Is Automatic Control's Friend and Foe." Around this slogan was formulated a science within a science, treating of lags, delays, oscillations, flywheel effects, reservoir effects, feedback loops, etc.—too technical for a tabloid history—which proved itself applicable to all industries.

11. "Robot Analyzers" and *"The Manless Factory."* Obstructing the applications of all sciences has been, and is, the "my-problem-is-different" attitude. Nearly all chemists accepted, soon or late, the idea that the properties and composition of the effluent product can be exactly pre-determined by controlling the process conditions. But most chemists (and many chemical engineers) qualified as a wild dream the Instrumentation doctrine that the delicate, humanly-manipulated, weekly or daily tests of products in quality-control laboratories could be automatized in such manner that the test results would command (or "reset") the process-condition controllers. Many still think it a wild dream, but their ranks began to dwindle in 1940 when analyzing methods—both actual and possible—were classified and evaluated with the specific purpose of bringing to light the possibilities of "telemetering" the quality-control laboratory so as to command the process-condition controllers.[1] Further inroads on the skeptics followed the 1942 American Chemical Society session on the manless factory.[2] Of course it is not always obvious or easy. Here are two tough problems:

I.—Food Products. Here, Quality is made up of elusive "qualities" as well as measurable properties. Food-product chemists could adopt the indirect or collateral method of automatic control. The dairy industry furnishes a good example: The quality of non-homogenized pasteurized milk depends chiefly on measurable properties such as the cream line and the bacteria count. These properties depend on the temperature and duration of the pasteurization process. Health authorities and dairymen act as the "master controller" whose "signals" in the shape of codes "command" the control instruments on pasteurizers.

II.—The Blast Furnace. At present, pig-iron quality is determined by time-consuming analyses and tests; and smelting process conditions are not fully controlled because all the interdependent variables have not yet been reduced to isolated measurables. So it usually takes *years* for the laboratory "signal" to accomplish important process "resets" such as ordering changes in furnace dimensions to alter the durations of the processes in the various zones, ordering changes in proportions of raw materials, etc. Even minor "resets" during runs involve "characteristic times" of days or weeks. Therefore it seems rash to propose instruments which will instantly measure the quality of pig iron as it is tapped (even before: in the hearth) by measuring its composition and its future properties as a solid—and which will transmit their sets of findings to robot-brain instruments which will command the smelting-process condition controllers. Yes, rash, but reasonable!

Yesterday's lab tester or analyzer should be the plant instrument of TODAY, not of a remote to-morrow.

(1) INSTRUMENTS, March 1940, pages 63, 84-85.

(2) Official title was "Stepping Up the American Chemist's War Effort Through Instrumentation" but the actual theme was "The Manless Factory, with Particular Reference to Minimizing Lags and Delays." It was not published by the ACS at the time. It should be published.

The Shadowgraph Recording Method

By D. L. SUPERNAW, Ordnance Research Laboratory, The Pennsylvania State College

Introduction

In all fields of research and development it is necessary to have some method for recording information derived from or common to any observation or experimental operation. The manual tabulation of observations at regular times, or event intervals, may be satisfactory for some types of work, but a continuous record is more desirable and often absolutely necessary.

Several factors govern the selection of a recorder for any project:

1. Characteristics of each function to be recorded.
2. Number of functions to be recorded.
3. Duration of recording time.
4. Physical conditions common to operations under which the recorder must operate.
5. Available power for running the recorder.
6. Available space for the recorder and associated equipment.

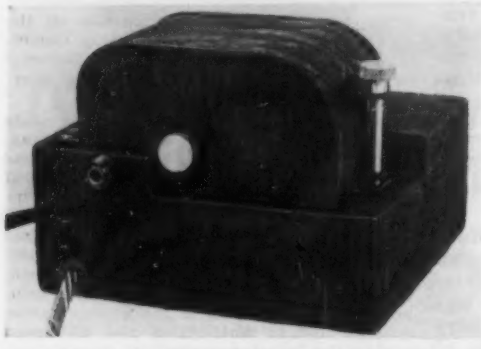


Fig. 1. Seven-element Shadowgraph Recorder.

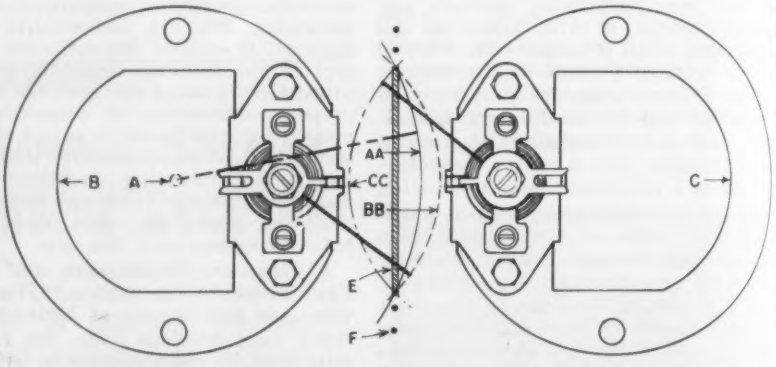


Fig. 2. Arrangement of instruments and slot (actual size). A—Location of pivot of pressure-gage pointer. AA—Path at end of pressure-gage pointer. B—Voltmeter. BB—Path at end of pointer of voltmeter B. C—Voltmeter. CC—Path at end of pointer of voltmeter C. E—Slot forming chord common to path of the three instruments. F—Four impulse ports, two on each side.

For work in the laboratory, the first three factors generally determine the selection of a recorder. Equipment should be chosen which will transfer the desired information to a continuous record with a minimum amount of loading imposed by the recorder input on the source under observation. Numerous recorders are available on the market and, if the requirements are not unusual, the only problem is to select the most desirable type of instrument and possible associated equipment.

Field operations where available space is not a problem may include factors 4 and 5. The recorders should be rugged enough to withstand normal handling and service in the field. Batteries and converters or a portable power plant offer a possible solution for a-c. power supply requirements if a constant frequency is not necessary. Standard recorders with d-c. drive motors may be better suited to this general class of operation.

When all six factors must be considered and the available space is exceptionally small, the problem of recording can be serious and the design and building of suitable instruments may be a major contribution to the progress of a particular project.

The two recorders described in this article fall in this group. They were designed for use in guided missiles where the total available space was extremely small and where it was not possible to use conventional recording methods.

The design of the Shadowgraph recorder originated as a method for meeting these problems. The results were so satisfactory that this method of recording can be used to advantage where its compactness is not necessarily a contributing factor. The specific requirements on the first instrument are discussed in some detail as they help to amplify the conditions which led to its particular design, although the second recorder which includes all the basic principles of the first is much better suited to fabrication and is recommended where this type of instrument can be used.

The Seven-element Recorder

The first of the two recorders to be described (Fig. 1) had to be designed within maximum over-all dimensions of 5″ × 5″ × 3¾″. Over a period of five minutes, it was desired to record four "impulse" or "off-on" types of information, one pressure variation from 0 to 25 lbs./in.^{2}, and two separate differential voltage variations of 3-0-3 volts d.c. across an 1800-ohm load. An additional complication in recording these two sources of voltage was keeping the shunting effect of the recorder input higher in resistance than 25,000 ohms. The functioning of the equipment under observation would have been affected by greater loads.

Fortunately, the rate of change in voltage values was slow enough to permit the use of any recording element with a response equal to that of a voltmeter. The rate of change in pressure, likewise, was slow: it did not exceed 10 lbs./in^2 per second.

In normal operations, the recorder would not be subject to excessive vibration or shock, but it was desirable to construct the instrument to withstand operating conditions similar to that experienced on mobile instruments used on road equipment.

With these general specifications established, it was necessary to devise some method of recording that could be completely incorporated in a housing 5″ × 5″ × 3¾″. All of the conventional methods considered were rejected either because of their excessive size or because they required auxiliary equipment such as amplifiers.

Since the visual observation of sensitive voltmeters (10,000 ohms per volt) had constituted a suitable check on simulated "runs" in the laboratory, a moving picture of the two voltmeters and the pressure gage would give a satisfactory record on actual runs. Here again we were limited by the necessary distances between all of the elements in the optical system as well as by the size of the mechanical elements. It was still desirable to take the information from the voltmeters and pressure gage photographically, as this imposed no load on these instruments and the record would be correct within the accuracy of the instruments. A system was devised whereby moving sensitive paper could be exposed through a mechanical slot by a point source of light so that any obstruction between the light and the slot would cast a shadow and leave unexposed a line on the sensitive paper. By arranging the voltmeters and pressure gage so that the slot formed a chord com-

mon to the circular paths at the ends of their indicating pointers, it is obvious that the pointers would cast a shadow on the sensitive paper. These shadows would be somewhere within the limits of the length of the slot, depending on the position of the pointers, and would appear as separate variable traces on the developed paper.

This arrangement, as shown in Fig. 2, was made possible by removing the two voltmeter "movements" [mechanisms] from their cases, removing their scales, and rotating the moving-coil assembly 180°. Triplett 2″ "Type 221T" 100-0-100 microammeters were used, as their moving-coil assemblies are in one piece and held in position by two screws which secure them to their permanent-magnet fields. It is only necessary to take out the screws, carefully remove the moving-coil assembly, and replace it 180° from its original position. A 30,000-ohm series resistor was used to give the 3-0-3 volt scale.

The Bourdon tube pressure gage is not shown. Its "movement" is mounted inverted directly above Voltmeter B with the pivot of its pointer at the location indicated by A. Since the full sweep of gage pointer is not used, a gage must be selected which has the desired range over the number of degrees required to sweep the slot.

Two ports at each end of the slot act as apertures through which the sensitive paper can be exposed by individual light sources to give the four "impulse" or "off-on" records. The location of the impulse traces identifies them, but the three variable traces require individual identification.This was made possible for the pressure-gage trace by reason of its characteristics; different widths of traces for the two voltmeters were obtained by turning one voltmeter pointer on edge while the other was left with its wide surface parallel to the sensitive paper: the different widths of the resultant shadows gave the desired difference.

In Fig. 3 we can see the arrangement of these various components less the drive and reduction gear. The slot O and four ports are in a straight line on the apron which supports the Bourdon-tube pressure gage and also acts as a housing N for the recorder. The instrument base H, which is made of Bakelite and acts as an insulating medium between the instruments, supports the two voltmeters as well as the light source G for the slot and the lamp housing F which houses lamp E 1, 2, 3, and 4 for the impulse ports. Plastic light guides C 1, 2, 3, and 4, formed from a ⅛″ Lucite rod, are used to direct the light to the four ports, as there is not enough room directly under the ports for the lamps and sockets. (The first two light guides in Fig. 3 have been cut away so that the pointers of the two voltmeters and of the Bourdon gage are in evidence under the slot.) Lamp G is held in place on the Bakelite base with a clamp so that its filament is 1¼″ below the center of the slot. Masking tape (not shown) is wrapped around the upright section of each light guide to eliminate stray light interference in the slot. The motor and reduction gear as well as the voltmeter and light-source assembly are secured to base I, which completes the housing.

The lamp housing F was made in two pieces. One half was machined with four ⅛″ openings (to accommodate the Lucite guide rods) on one side and four openings on the opposite to house the glass bulb section of the lamps. The other half was machined with four special threaded holes to match the lamp bases, complete with base terminals to act as sockets for the impulse lamps. This arrangement isolated the light from each source at a location where the space was available. The light was directed from this location through the four plastic rods to the proper ports. Pilot type lamps were used for the light sources.

Still referring to Fig. 3, the magazine K was made to hold 14 feet of orthochromatic extra-thin "Type XXA" sensitive paper (0.004″ thick) cut 1¾″ wide. With paper speed of 2½ feet per minute, a 5-minute run required 12½ feet of paper which left 1½ feet for pre-run and post-run calibrations. Supply spool M and take-up spool L were made as large as possible within the limits of the total recorder height of 3¾″. The diameter of the drum on spool L was made as large as possible (and still hold 14 feet of paper) as this larger diameter gave a more constant paper speed throughout the run.

A Delco governor-controlled 6-volt motor and a Telechron "Type B" reduction gear installed in the recorder drove the take-up spool in the magazine. A gear on the magazine engaged a gear in the recorder when the magazine was in place on the recorder housing.

The motor and reduction were special products of World War II and are no longer available, so no detail is given on this part of the recorder. Any conventional motor and gear reduction of suitable size would be satisfactory in the design of a recorder of this type.

As there is no optical system of lenses, several factors must be considered for obtaining a sharp trace. The pointers must be kept as close to the sensitive paper are possible and the light source as far away as the design will permit with a minimum recommended distance of 3″. This is advisable, since the filament of the exposure bulb does not give an ideal point source of light. The bulb should be installed with a plane of its filament at right angles to the sensitive paper. To eliminate reflections (which also detract

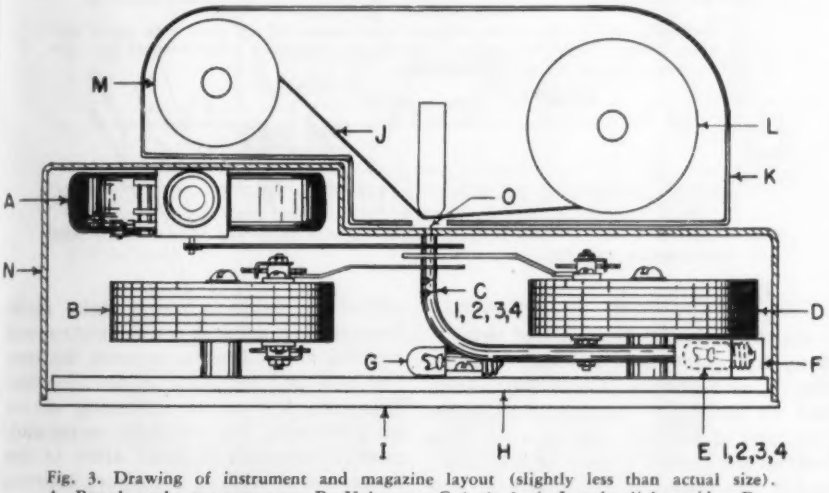


Fig. 3. Drawing of instrument and magazine layout (slightly less than actual size). A—Bourdon-tube pressure gage. B—Voltmeter. C 1, 2, 3, 4—Impulse light guides. D—Voltmeter. E 1, 2, 3, 4—Impulse exposure lamps. F—Impulse lamp housing. G—Slot exposure lamp. H—Bakelite instrument base. I—Recorder base. J—Sensitive paper. K—Magazine housing. L—Take-up spool. M—Supply spool. N—Recorder housing. O—Slot.

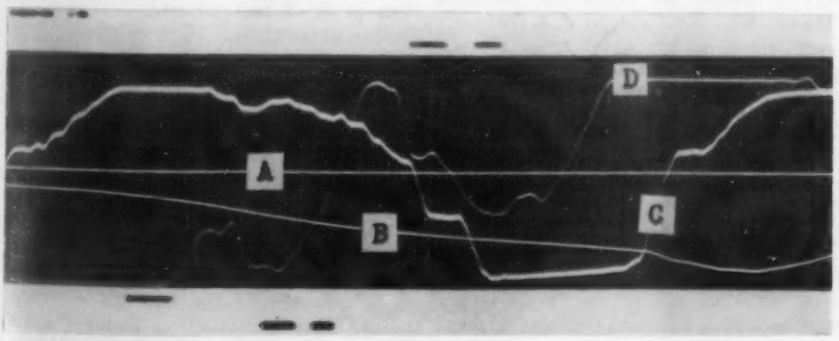


Fig. 4. Seven-element Shadowgraph record (actual size). A—Reference trace. B—Pressure trace. C and D—Voltmeter traces. Four impulse traces are on margins of record.

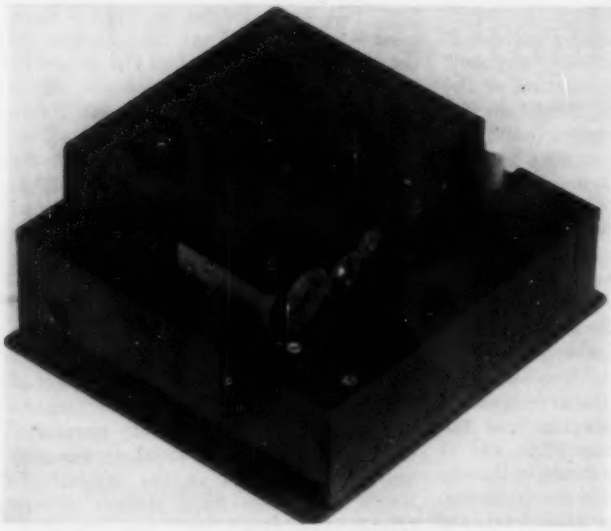


Fig. 5. The Eight-element Shadowgraph.

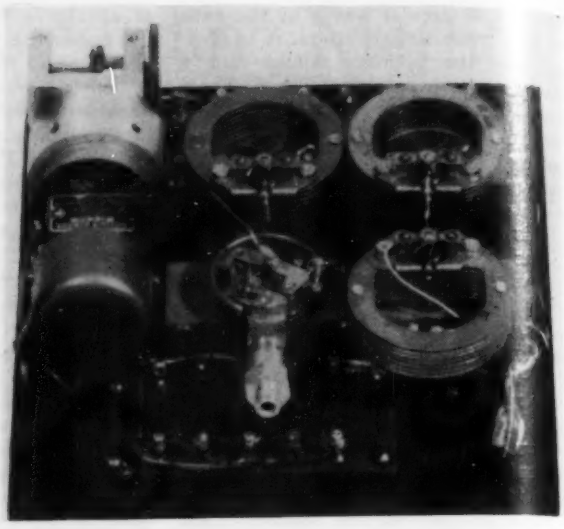


Fig. 6. Eight-element Shadowgraph with magazine and top plate removed.

from the sharpness of the trace) all surfaces common to the slot and light source should be given a coat of dull black paint. The slot width should not exceed 0.02", and the four impulse ports should not exceed 0.025" in diameter. Since it is necessary for the slot and ports to lie between the pointers and the sensitive paper, this apron should be a part of the recorder housing to eliminate any unnecessary additional space between these members. A piece of No. 28 wire is soldered across the center of the slot to form the reference line on the record.

Correct exposure is obtained at each light source by operating the lamp at the correct light intensity for a given paper speed. Speeds of approximately 1" per second or 5 fpm. will require full rated voltage on 6-volt 150-milliampere pilot bulbs while approximately 4 volts is required at speeds of 2½ fpm.

A photograph of a record run at 2½ fpm. is shown in Fig. 4.

Since the four impulse ports and the slot lie in a line at right angles to the movement of the paper, the time reference is the same for each trace. This is a great help in quickly visualizing the performance of the equipment under observation subsequent to the actual evaluation of the recorder.

This new recording method and this particular application have not been discussed with the idea of limiting the reader's conception of its possibilities. It is obvious that any of the instruments could have been replaced with a temperature indicator or any other instrument movement with a deflecting pointer. It is also possible to incorporate pointers mechanically actuated by a linkage to an external source of movement under observation. Low-torque voltage-dividing resistors which can be installed on various types of instruments or connected to mechanical movements offer an ideal means for transferring readings or positions to the voltmeters in the record.

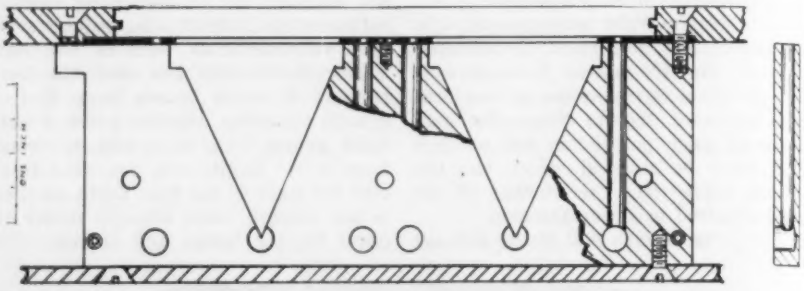


Fig. 7. Sectional view of light guide between cross sections of top plate with apron and bottom plate. (Right) Cross-sectional end view shows location of a ⅛" vertical hole and the 3/16" lamp opening for the impulse port.

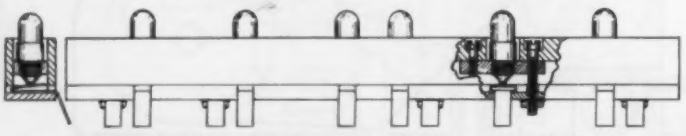


Fig. 8. Sectional view of lamp housing. (Left) Cross-sectional end view through lamp and contact-spring assembly.

The Eight-element Shadowgraph

As stated in the first part of this article, the eight-element Shadowgraph, Fig. 5, is better suited to fabrication and its design is recommended where this type of recorder can be used. This instrument is 6¼" × 6¼" × 3¾" high, and it has four impulse inputs as well as three voltmeter inputs and one pressure-gage input. Several factors contribute to the simplicity of its design, a major one being the use of a Mazda No. 325 airplane instrument lamp, rated at 0.19 amperes at 3 volts. This lamp is only 3/16" in diameter and ½" long. Its relatively small size as compared to a standard pilot lamp makes it possible to eliminate the plastic light guides used in the seven-element recorder. Additional ease in construction is made possible by using 3½" sensitive paper and exposing it through two slots with two instruments to a slot. The use of two slots makes it unnecessary to stack two instruments one above the other as in the first recorder. Construction is further simplified by using a metal light guide housing as a support for the instrument mounts as well as a support between the base and top plate of the recorder. Likewise, the motor mounting serves as a housing for the final worm-and-gear reduction and gear drive to the magazine as well as a support between the base and top plate of the recorder. The recorder with the top plate and magazine removed is shown in Fig. 6. The light guide is evident between the two rows of instruments.

The general construction of the light guide, and its location between the base and apron on the top plate, are indicated in Fig. 7. The two V cuts in the guide are directly below the slots in the apron, and the lamps lie in a 3/16" opening at the bottom of each V. Four ⅛" vertical holes in the guide, one in each end and two in the middle, lie directly below the four impulse ports in the apron, and their lamps lie in 3/16" openings at the bottoms of these holes. This construction isolates each light source and makes it possible to use the light guide for several other

purposes as stated. The lamp housing, Fig. 8, with sockets for the six lamps, is held in place at the bottom of the guide with two screws. The lamps are so arranged in the housing that their filaments are centered directly under their respective ports or slots. The housing is made of two pieces of Bakelite: one piece holds separate threaded brass plates which act as sockets for the lamps; the second acts as a retainer for the center spring contact.

A side view of the recorder with one of the side plates removed, Fig. 9, shows the arrangement of the parts as well as the multiple purposes served by the light guide F and the motor mounting G. Four side plates A slide into grooves in the top and bottom plates I and J to complete the housing proper of the recorder. These plates are clamped in place by a screw in each corner of the recorder.

The magazine, Fig. 10, has a constant-paper-speed drive which is obtained by using a driven rubber-covered drum to pull the paper from the supply spool and a slip drive on the take-up spool which otherwise has a higher speed than the rubber-covered drum. This conventional system depends on the friction between the paper and rubber-covered drum being greater than the friction of the slip clutch on the take-up spool. Tension between the paper and the drive drum is maintained by putting a slight drag on the supply spool. The magazine, which has a groove on two sides near the base, is held in place in the recorder by sliding it into a recess in the top plate on tongues machined into this part. The apron, which has the impulse ports and slots, is $\frac{1}{32}$" thick and is secured to the under side of the top plate across this recess. The drive gear of the recorder engages the gear chain in the magazine when the magazine is in place.

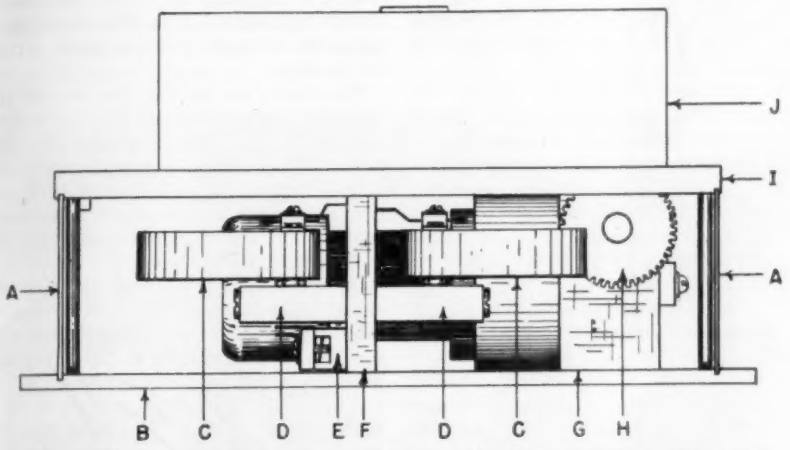


Fig. 9. Side view of recorder with one of the four side plates removed. A—Side plates. B—Base. C—Instrument movement. D—Bakelite instrument mounting block. E—Lamp housing. F—Light guide. G—Motor mounting. H—Recorder drive gear. I—Top plate. J—Magazine.

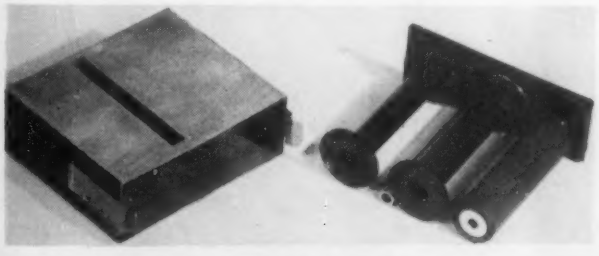


Fig. 10. Magazine with cover removed.

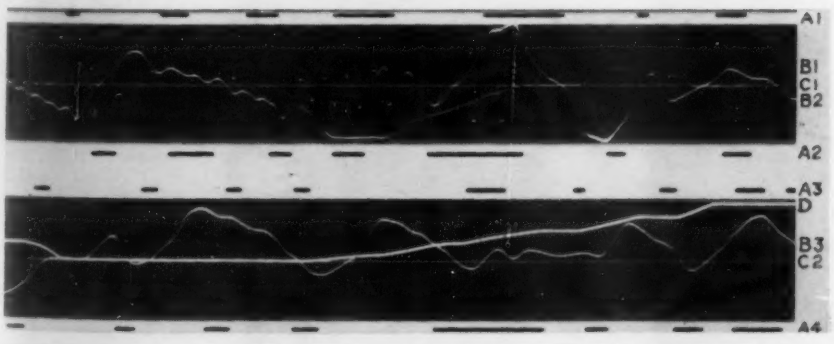


Fig. 11. Eight-element Shadowgraph record (ONE-HALF actual size). A1, A2, A3, A4—Impulses. B1, B2, B3—Voltmeter traces. C1, C2—Reference traces. D—Pressure trace.

The general construction of the magazine is evident in Fig. 10. The spool drum and gear chain are all mounted on a Dural end plate. The cover is held in place on the end plate by two spring catches. The closed end of the cover is $\frac{1}{16}$" brass, and the rest of the cover is $\frac{1}{32}$" sheet brass.

The magazine has a capacity of 25 feet of XXA orthochromatic extra-light-weight paper, $3\frac{1}{2}$" wide. Paper speeds are approximately 1", $\frac{1}{2}$" and $\frac{1}{4}$" per second. These speeds are obtained by selecting a quadruple-, double-, or single-thread worm and corresponding 30-tooth worm gear which are interchangeable on the motor mounting and drive-gear assembly.

The motor for driving the recorder is a Delco 27-volt "Type 5069230" with a built-in reduction and shaft output of 145 rpm. (These motors were used on computers and on aircraft control equipment and are available from various supply houses in quantities at $3 to $5 each.) A 48-pitch single, double-, or quadruple-thread worm is attached to the output shaft and drives a 30-tooth worm gear on a second shaft common with the drive gear to the recorder. As previously stated and in evidence in Fig. 6, the motor mounting accommodates this complete assembly. Metal parts of the recorder are made of 17ST Dural, anodized after machining, except for the magazine cover which is made of brass and given a coat of wrinkle paint. The gears are all standard 48-pitch spur or worm and gears. Ball bearings are used on the worm-and-gear reduction, and ball thrust bearings are used on the brake and slip clutch elements of the supply and take-up spools.

The resultant record is shown in Fig. 11. Identification of the traces is made possible by their width. Development of this record is a conventional procedure and only requires a few minutes. It is necessary to use a red filter on the dark room light when loading the magazine or developing orthochromatic paper.

The selection of voltmeters, pressure gages, or other recording elements for any specific requirement is limited to maximum "movement" diameters of $1\frac{3}{4}$". This dimension is common to 2" size electrical indicating instruments.

Space is available inside the recorder housing for series or shunt resistors used in connection with electrical "movements." The same is true if it is desired to use voltage-dropping resistors in series with the exposure lamps. In Fig. 6 two terminal boards can be seen as well as the resistors required on a particular application. No reference is made to their value, as their selection was made for a specific recording job.

It is hoped that this article may be a source of help in solving other recorder problems involving limited space, sensitive elements, low power requirements, and rugged characteristics.

A Portable Two-channel Recording Oscillograph for Battery Operation

By R. F. WILD, Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co., Philadelphia.

FOR certain uses there is a need for small self-powered recording equipment, these uses being the recording of vibrations in aircraft, mechanical structures, and machinery. In an attempt to fill the aircraft need, an experimental portable two-channel recording cathode-ray oscillograph, for use as a flight vibration recorder, was developed by the Brown Instrument Company for, and in coöperation with, the Technical Development Division of the Civil Aeronautics Administration.

The recorder is designed for simultaneous photographic recording of two input signals of any frequency between five and 300 cycles per second, and from two millivolts to two volts peak amplitude, as well as for recording of marking signals to provide a time base for frequency determination. The instrument is designed for battery operation, is completely self-contained and, therefore, independent of the availability of an external power source.

String-galvanometer oscillographs are available for simultaneous recording of several signals. However, the power requirements for driving low-impedance galvanometers suitable for signal frequencies of several hundred cycles would impose serious limitations on the weight and size of a self-contained instrument of this type.

Therefore, it was decided to design a cathode-ray oscilloscope with recording camera, requiring a minimum of power for operation, which can be more practically supplied from batteries in a light-weight, compact and self-contained instrument.

Fig. 1 shows the front view of the instrument with the location of various controls and operational switches. The size of the instrument is 6" × 12½" × 16½" and its weight, including batteries, is 35 lbs.

On the left side panel there are provided two input plugs, adapted to receive cable connectors connecting the instrument to pick-up devices, strain gage circuits, or the like.

Starting from left of the front panel, there are located two attenuator switches for controlling the amplifier channel input signals and two integrator networks which can be connected into the amplifier channels, in case velocity-type pick-up devices are used with the instrument. A selection of three integrator capacitors in each network is provided for coverage of the frequency range of input signals. A sweep switch permits selection of one of three cathode-ray sweep frequencies as well as the corresponding one of three marking signal frequencies. A viewing hood is located below the sweep switch. The cathode-ray tube traces can be viewed through the hood, for checking adjustments until immediately before recording.

To the right of the sweep switch is a power switch for opening and closing eight battery circuits. Below this switch is a shutter push button for opening the film shutter and for closing the print switch for recording of traces. Finally, at the extreme right, a function switch is located. The function switch can be turned clockwise to different positions for viewing and for recording of the input signals and the marking signals.

A film-pack well is located at the extreme right center of the instrument, and a second well for a spare pack is located directly below.

An exploded illustration of the instrument, Fig. 2, is a view of the upper third of the instrument occupied by the amplifiers, marking signal generator, sweep circuits and switches; the center, occupied by the cathode-ray tube, centering and intensity adjustments, and the camera. The lower third is reserved for batteries.

The electronic circuits, shown in Fig. 3, include two preamplifier channels, an electronic switch, a multivibrator circuit for operating the switch, a marking signal generator, a sweep generator for recurrent and single sweep, and the cathode-ray tube circuits. These circuits include ten miniature tubes and one medium-size tube, all designed for battery operation, a cold-cathode gas-discharge tube, and a cathode-ray tube.

Each preamplifier channel includes an input attenuator, having a total resistance of about one megohm, divided in eight steps, each about 30% of the preceding, from one to 0.0001. Each channel includes two amplifier stages, using 1L4 tubes, and compensated for low-frequency amplification to provide a relatively small drop in gain from 300 to 5 cps.

Between the first and second stages, an integrator network, comprising a resistance-capacitance circuit, can be inserted at will. Three integrating capacitors of different values are selectively connected into the integrator network, depending upon input signal frequencies.

The electronic switch, for mixing the amplifier output signals at a switching rate of about 20 kc., includes two 1R5 tubes. These tubes, operating with different bias voltages on the second control grids, effect permanent separation of the two input signal traces on the cathode-ray tube screen.

The switch tube circuits are compensated for low- as well as high-frequency amplification, since they must now pass a band from 5 cps. to a frequency approaching one-half megacycle.

The electronic switch is excited by a multivibrator circuit, including two 1S4 tubes, operating with positive grid bias, and producing out-of-phase square waves of about 20 kc. These output

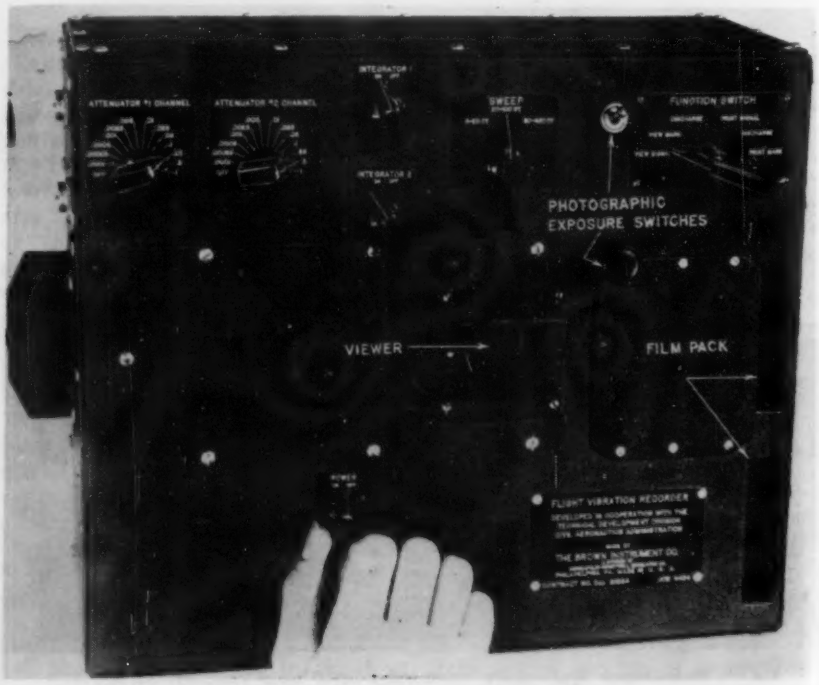


Fig. 1

waves are applied to the first control grids of the switch tubes. The relatively high switching frequency was chosen to minimize gaps in the signal traces, due to switching of the cathode-ray between traces. Care is taken to generate square waves with a minimum of distortion and also for preserving the wave shape and minimizing the halo between signal traces.

As a rule multivibrators produce waves which have a horizontal portion and a sloped portion during alternate half-cycles and are not truly square waves. In the present instrument, care has been taken to apply the multivibrator output waves with such phase and magnitude to the switch tubes that the latter are fully cut off during occurrence of the sloped wave portions. In this manner, distortion of the multivibrator output waves is made harmless.

A final wide-band amplifier stage, using a 1L4 tube, is coupled to the electronic switch. This amplifier stage is compensated for low- and high-frequency amplification and is connected to the vertical deflecting plates of the cathode-ray tube for certain positions of the function switch.

The marking signal generator is a resistance-capacitance relaxation oscillator, including a twin triode tube, Type 1G6.

One of three different resistors can be selectively connected into the common cathode circuit by means of the sweep switch, to enable generation of marking signals at 24, 40 and 100 cps. respectively. This circuit is a modification of a known relaxation oscillator and produces a different wave form at each of the three operating frequencies for the purpose of convenient identification of marking frequency.

Each of the wave-forms has steep wave fronts, providing a sufficiently accurate time base. The output circuit of the marking signal generator is connected to the vertical deflecting plates of the cathode-ray tube in certain positions of the function switch.

The marking signal generator is permitted to operate only during viewing and recording of marking signals. At all other times, it is made inoperative by shorting the control grid of one of the tubes to ground. This obviates the need for elaborate shielding to prevent the marking signal from feeding into the amplifiers; space limitations would make proper shielding difficult.

The sweep circuit is capable of producing recurrent sweep waves for viewing the signal traces and single-sweep waves for recording these traces.

A single sweep for recording was chosen because the two input signals to be recorded need not have equal or even commensurate frequencies. Therefore, it would not always be possible to find a recurrent sweep frequency commensurate with the input signal frequencies. The recurrent sweep is intended for viewing only, to check the presence of signal traces and adjustment of their amplitudes. It is not provided with any fine frequency adjustment.

To obtain an input signal record which can be conveniently analyzed, three sweep frequencies are provided, so that a record of not less than two complete cycles and not more than 10 complete cycles of any frequency in the band between five and 300 cps. can be obtained. These sweep frequencies are 2.5 cps. for input signal frequencies from five to 25 cps., 10 cps. for input signal frequencies from 20 to 100 cps., and 40 cps. for input signal frequencies from 80 to 300 cps.

The sweep switch is used to select recurrent and single-sweep frequencies as well as the marking signal frequency in a single switching operation.

The sweep circuit comprises a large capacitor charged through a 1S4 pentode tube, thus obtaining a linear sweep voltage across the capacitor. The sweep frequency is adjusted by varying the control grid bias voltage of this tube, thus varying the capacitor charging current. For recurrent sweep the capacitor is discharged through a cold cathode gas-filled tube, Type 1C21.

For single sweep the gas tube is disconnected from the circuit by means of the function switch, the capacitor disconnected and discharged by short-circuiting. The single sweep is initiated by connecting the capacitor again into the charging circuit by means of the print switch which is mechanically actuated by the film shutter push button. The sweep voltage is applied by direct coupling of the capacitor to one of the horizontal deflection plates of the cathode-ray tube, to avoid deflection distortion by coupling networks.

A two-inch cathode-ray tube, Type 2AP5, is used, yielding a blue trace favorable to photography; its associated circuits include three controls for centering the input signal traces and marking signal traces vertically and horizontally, as well as controls for focusing and intensity.

Because the sweep speed varies by a ratio of 16:1 for fast and slow sweep, a control coupled to the sweep switch is provided for applying different bias voltages to the control grid of the cath-

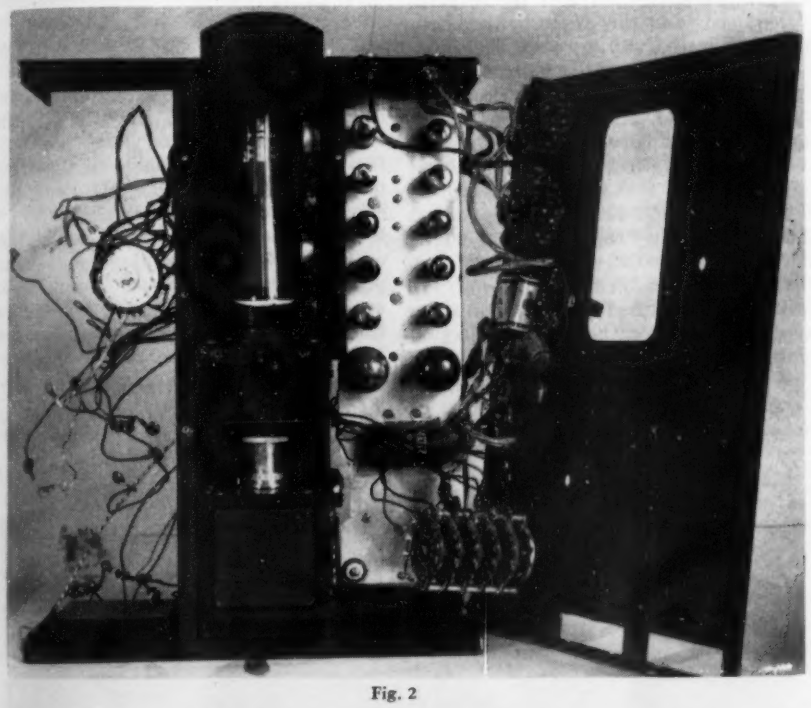


Fig. 2

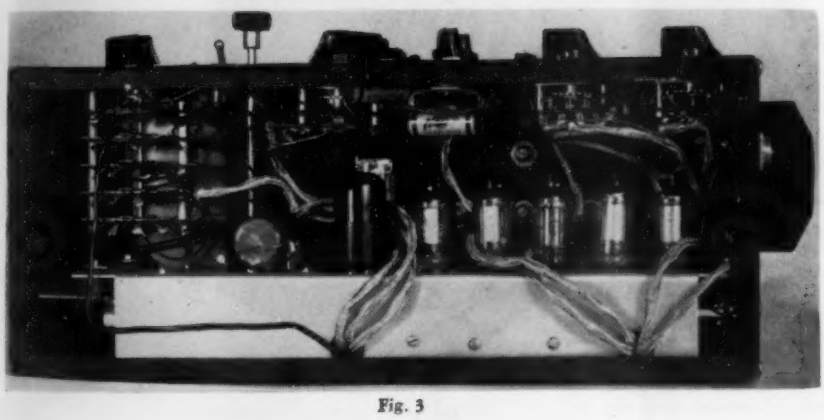


Fig. 3

ode-ray tube for each of the three sweep frequencies. In this manner the cathode-ray intensity becomes more evenly matched to its deflection velocity, resulting in a more nearly constant intensity of the photographic record.

The cathode-ray velocity is greater for input signal traces than for marking signals because of their greater amplitude and because of the interruption of the input signal traces by the action of the electronic switch. Since this action would result in producing a considerably more intense trace of marking signals than of input signals, contacts are provided on the function switch for applying different bias voltages to the control grid of the cathode-ray tube for marking and input signals. The traces of both signals are of substantially equal intensity.

The function switch, above referred to, is used to make proper circuit connections in the instrument required for its various functions, namely:

1. Viewing of the vibration signals with periodic sweep.
2. Viewing of the marking signals with periodic sweep.
3. Discharging of the sweep capacitor before printing on single sweep.
4. Printing of the vibration signals on single sweep.
5. Discharging of the sweep capacitor before printing on single sweep.
6. Printing of the marking signals on single sweep.

The camera arrangement for viewing and recording the signal traces is shown in part in Fig. 2. This arrangement comprises a reflector positioned between the cathode-ray tube screen and the camera lens for reflecting the cathode-ray traces through the viewing hood for direct viewing.

When the viewing hood is closed for recording, the reflector is automatically depressed and moved out of the optical path between the screen and the lens. The camera housing is provided with an internal shutter which normally provides a light-tight seal to prevent extraneous light from reaching the film pack during viewing of the traces. The shutter, obviating the need for reinserting the slide into the film pack after each exposure, is actuated by means of the shutter push button mounted on the front panel. The shutter is depressed when records are made.

The camera is equipped with an F2 lens having a focal length of 50 mm. and records are made on film pack, size 2¼" × 3¼" with 12 exposures. In commercial film packs each exposure bears a number, permitting easy identification of records.

The power and bias voltage supply for operation of the instrument consists of 22 batteries and four groups of button type bias cells, all housed inside the case, occupying about 330 cubic inches and weighing approximately 20 lbs. This source supplies 1.35 amperes to tube filaments, the heaviest load being the cathode-ray tube filament with a current drain of 0.6 amperes. A total current of approximately 70 ma. is supplied to the tube circuits by eight 67.5-volt batteries. The shortest life of any battery is approximately eight hours of continuous operation. A terminal board is provided in the rear of the instrument for convenient checking of battery voltages.

Operation and Performance

The preparatory adjustments to be made before recording are few and simple. The viewing hood is opened to allow observation of the input signal traces

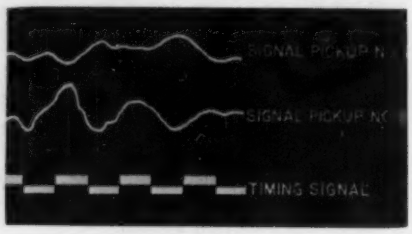


Fig. 4

on the cathode-ray tube screen, while the function switch is in "View Signal" position. The attenuators are then adjusted for proper input signal level, the integrators connected into the circuits if required, and the proper sweep frequency selected. By turning the function switch into the "View Mark" position, a visual check of the marking signal is provided. After all adjustments are made, the viewing hood is closed, removing the reflector from the optical path.

The function switch is advanced through position "Discharge," in which the sweep circuit condenser is discharged, to position "Print Signal," in which the amplified input signals are applied to the cathode-ray deflection plates.

When the push button on the front panel is depressed, the light path is freed between the cathode-ray tube screen and the film by moving the shutter out of the optical path. When this button is depressed, the print switch is also actuated, causing the sweep circuit capacitor to become charged and the cathode ray to traverse the screen once, thereby leaving a permanent record of the input signal traces on the film.

After turning the function switch through the second "Discharge" position to the "Print Mark" position, the same operation is performed for recording the marking signal.

Fig. 4 shows the type of record obtained, in which the upper two traces represent the input signals, while the lower trace represents the marking signal, provided as a time base.

Conclusion

The instrument described was designed primarily for the study of vibration and dynamic strain in mechanical structures and machinery. It has a high input impedance and is intended for use with vibration pick-up devices and strain gages. Owing to its light weight, compactness, ease of installation, and simplicity of operation, it may be of interest to those concerned with such studies.

Tests made by the Technical Development Division of the Civil Aeronautics Administration have shown the instrument to be valuable in the study of flutter in aircraft, supplementing equipment weighing between 300 to 500 lbs. and requiring an installation time up to two weeks. This instrument makes possible vibration studies in small aircraft, where space and weight limitations make the use of bulky equipment impossible.

The instrument is likewise useful for simultaneous recording of any two input signals, regardless of their origin.

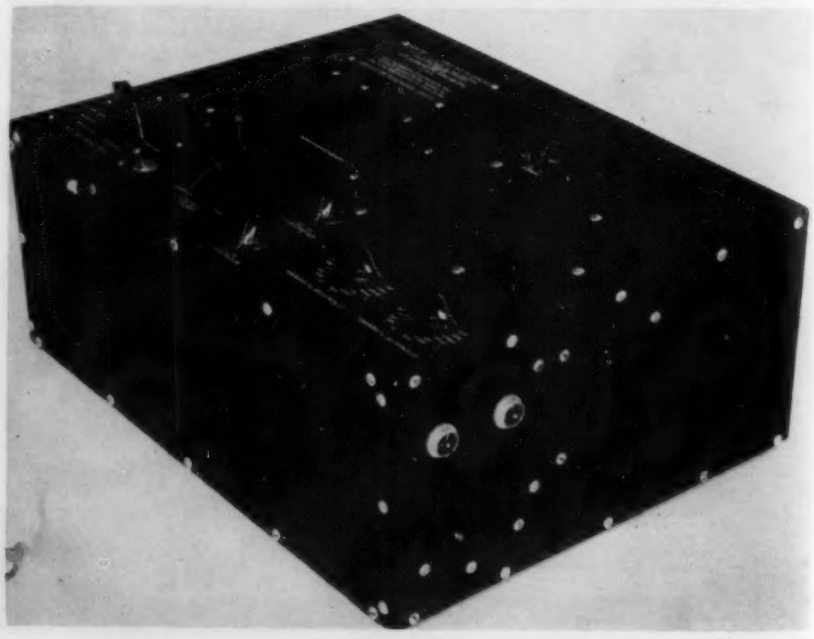


Fig. 5

A New Method for the Measurement and Control of Consistency of Thin Stock in Pulp and Paper Mills

By WILBUR F. PRAY, Askania Regulator Co., Chicago, Ill.

WATER is the great common carrier in the manufacture of pulp and paper. And one of the ever-present problems in the industry is, and always has been, how to maintain just the right mixture of pulp and water to suit the requirements at each particular point in the process.

This mixture, or proportion, commonly called consistency, varies from ¼ lb. of pulp and 99¾ lbs. of water to 12% pulp and 88% water—and even higher if it can be handled.

The manufacture of pulp and paper is really a series of continuous steps wherein the pulp is diluted and thickened, and also pumped, screened, washed, bleached, beaten, refined, etc. And for each of these steps there is an optimum consistency which, if properly determined and maintained, will result in any one, or all, of many greatly-to-be-hoped-for results: less power per ton, more production, less rejection of good pulp, higher efficiency, less labor, cleaner pulp, higher quality . . . and other results more dreamed about than realized.

Although the paper industry is quite old, it is only about thirty years ago that attempts at measuring and controlling stock consistency began to meet with any success.

It had long been known that as the consistency of stock increased, more power and larger pipe lines were required to transport the stock. This very simple characteristic produced also a sort of self-compensating consistency regulation. That is to say, as the stock thickened, less of it flowed, and vice versa. Possibly this kind dispensation of providence delayed the birth of any real attempts at true consistency regulation until a man in Glens Falls, New York, whose name has since become famous in the industry, used this principle—which everyone knew but never did anything about—to build the first real consistency regulator. In effect he put to work this fact that in the behavior of any mixture of pulp and water there is a relation between viscosity and consistency and if other factors (which may be minor but do enter into the picture somewhat) are neglected, the two may be used interchangeably. So, the problem reduced itself to finding some way to measure changing viscosity or, if you will, loss of head in a pipe line due to friction.

The various ways in which this principle has been applied since that time are numerous and highly ingenious. It is not the purpose of this article to detail them although a few might be mentioned: loss of head through a friction tube or in an open channel, changes in density, changes in torque required to drive a propeller or paddle in the stock and similar methods.

It has been well said that the perfect consistency regulator has yet to be invented.[1] Nor is it the purpose of this article to make any claims to the invention or discovery of the perfect consistency regulator.[2] What this article is about is the fact that all of the existing viscosity-consistency detectors and regulators with which the author is familiar leave practically untouched a wide field in the pulp and paper industry—*the consistency range of about one and one-half percent and below.* To further explore this statement, it is interesting to look at a plot of the information found in Cameron's Hydraulic Data on the behavior of pulp stock in pipe lines (Fig. 1). Here we see that the consistency-viscosity relationship is very marked from at least 2% up. Below this point it is plain that any method of consistency detection and control which depends on this relationship is, to say the least, likely to get into trouble. If this is accepted—and each reader must make up his own mind on this point—it is obvious that there is a field of consistency regulation which has been practically untouched. Additional evidence to this end lies in the fact that consistency regulation in these low ranges is practically unknown in the pulp and paper industry today.

Is it then not clear that if regulation is to be effected in this low range, another approach than that of the consistency-viscosity relation must be found? As a matter of fact another approach has been made—and by at least three different people, all of whom were working in the same direction apparently entirely unknown to one another. This approach took advantage of another well-known fact: that consistency had an effect on the *drainage rate* of the stock when it was laid on a wire or perforated cylinder. To illustrate the principle, a diagram of such a consistency measuring set-up is shown (Fig. 2). A mechanism similar to a pulp decker is constructed and stock is supplied to it at a constant flow-rate. The resistance to flow caused by the stock formation on the upstream face of the cylinder will cause a variation in head of the water upstream from the cylinder which will be proportional to some characteristic of the

(1) Frederick Wierk, *Paper Trade Journal*, July 11, 1940.

(2) As a matter of general interest there seems to be a universal demand, or shall we say hope, on the part of pulp and paper men for a consistency detector which will go in the line like a flowmeter and control the addition of dilution water at the suction end of the pump. Any bright boys having ideas on this subject will have an interested and sympathetic listener in the author of this article.

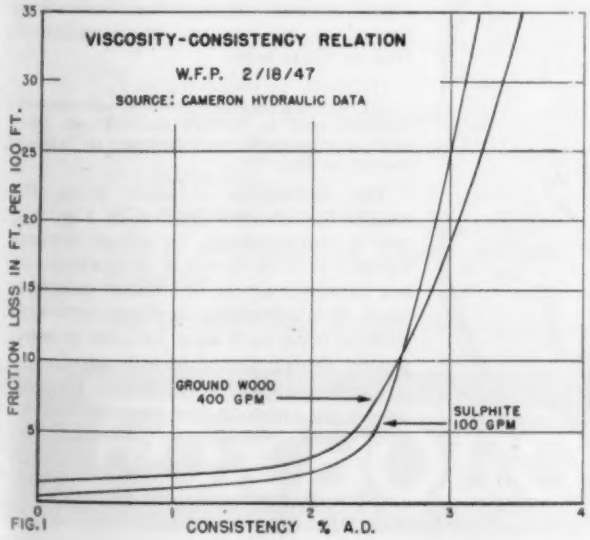


FIG. 1

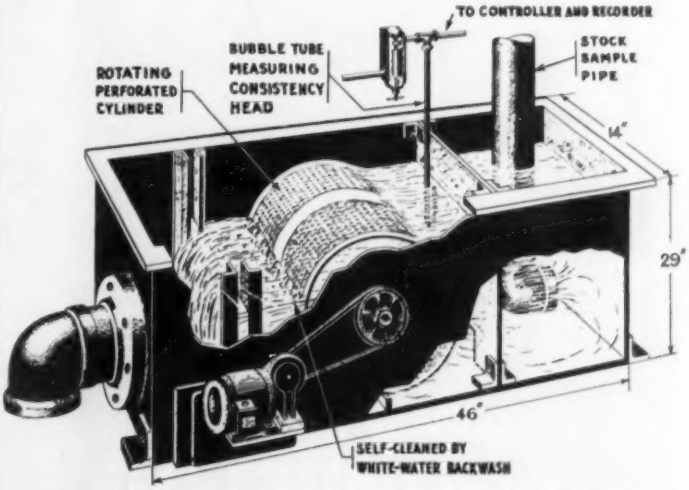


Fig. 2. A practical embodiment of the new method, designed to measure stock consistencies in the range from 0.1% to 1.25%.

stock. This characteristic, for want of a better term, is called drainage rate and is a combination of at least two definite properties, namely, consistency and freeness, plus some minor variables as yet undetermined. If constant freeness is assumed (and it may be assumed with the same stock) Fig. 3 shows the relation between the upstream head in the detector box and consistency variations as determined under laboratory conditions. It will be seen that this relationship is linear and can be used as the primary measuring indication in automatic consistency regulation. Fig. 4 shows the result of experimental data taken in a sulphite mill screen room that shows that, at least within the limits of routine mill laboratory tests, the relationship is still sound.

Fig. 5 shows a 24-hour record of consistency variations as recorded by a detector box in operation on the stock as it is pumped from the blow pits to the screen room in a sulphite mill.

The proposition is advanced, therefore, that for any process in the pulp mill where freeness is relatively constant, i.e., unrefined pulp in any knotting, screening, washing, filtering or wet machine operation and the like, a method is available for detecting, measuring and controlling, with reasonably high reliability and accuracy, consistency variations in the low ranges not susceptible of adequate handling by previously-accepted viscosity-consistency methods. The question then will be asked, "What of the multitude of applications in the paper mill or the ground wood mill where the stock is subject to wider freeness variations?"

It is a good question and can only be answered conditionally at the time. The manufacture of pulp and paper is still an art and not an exact science. It is still a problem of handling a multitude of sometimes unrelated and usually difficult-to-measure variables. For instance, consider the stock supply to the vat of a cylinder machine. The ideal which the paper maker is looking for is a supply of stock at a constant weight-rate of dry fibre which will always act on the cylinder in the same way or, roughly, have a constant drainage and formation characteristic.

Now the control means under discussion is made up of a conglomeration of these two factors (consistency and freeness) which, when added together, mean weight-rate plus drainage-rate.

The author can possibly be accused of wishful thinking but it is conceivable that if, on any given Fourdrinier or cylinder machine this characteristic (call it "X" if you wish—made up of consistency plus freeness plus unknowns) is held constant by some automatic means, it might reduce the number of variables which plague the operator, and wind up in an improvement of the process. After all, the way to judge these things is not how near absolute perfection are the results but how much improvement, if any, can be had over what now prevails.

So far, this article has described a new method of *measuring* this elusive quality of paper stock and little has been said about what to do with the indication from the measuring element once it has been secured. At this point, however, it is proper to state that this indication is a *good* one for automatic-control purposes—and to explain what is meant by a "good" indication or signal. Instead of advancing our own definitions and criteria, we shall quote the only author who has analyzed and classified indications and their numerous properties. In his most recent discussion[3] of the importance of the *quality* of the indication, M. F. Behar declared that "the proper performance of a controller depends, as does that of a manager, on the correctness and timeliness of the information which it receives" and he classified indications according to various basic schemes. One of these was:

(1) *Static* or no-moving part;
(2) *Kinetic* or mechanical-displacement. (Kinetic may be further divided into *kinematic* or "no-force" and *dynamic* or "accompanied by force.")

The indication obtained from the measuring element shown in Fig. 2 is not a microvoltage or other delicate signal; it is a dynamic indication—an air pressure up to 10" water column—ideal for actuating a diaphragm-type control relay such as a jet-pipe or other sturdy device suited to mill service.

As to "*correctness*," there is practically no error in the measurement of hydrostatic pressure by a bubble-pipe

(Continued on page 568)

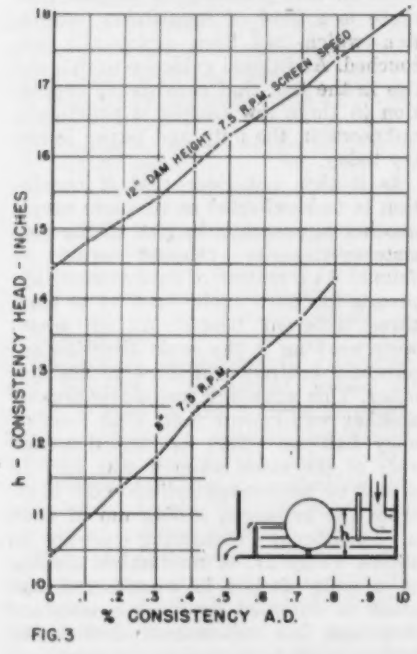


FIG. 3

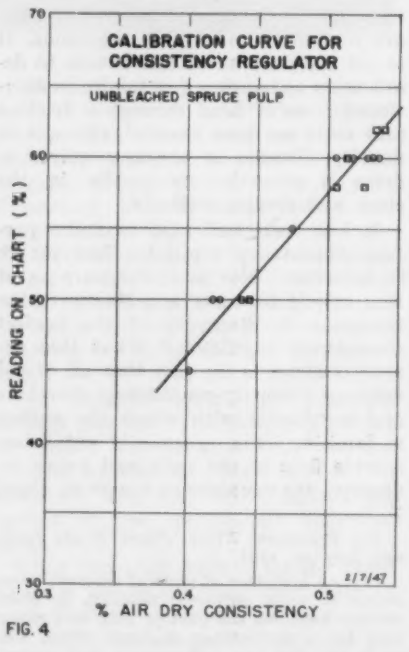


FIG. 4

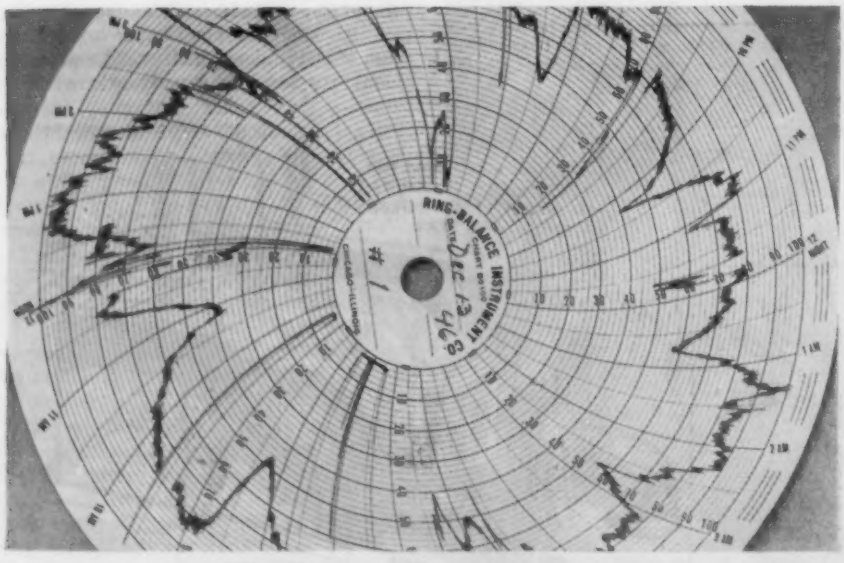


Fig. 5. Record of *uncontrolled* screening operation. Point 50 on chart (linear mid-point) represents 0.3% consistency. Total chart range equals 5" change in consistency head. Each ¾" change in consistency head equals 0.1% change in consistency with this particular stock, which is unbleached unscreened spruce sulphite.

(3) M. F. Behar, *Instruments*, Aug. 1946, page 446.

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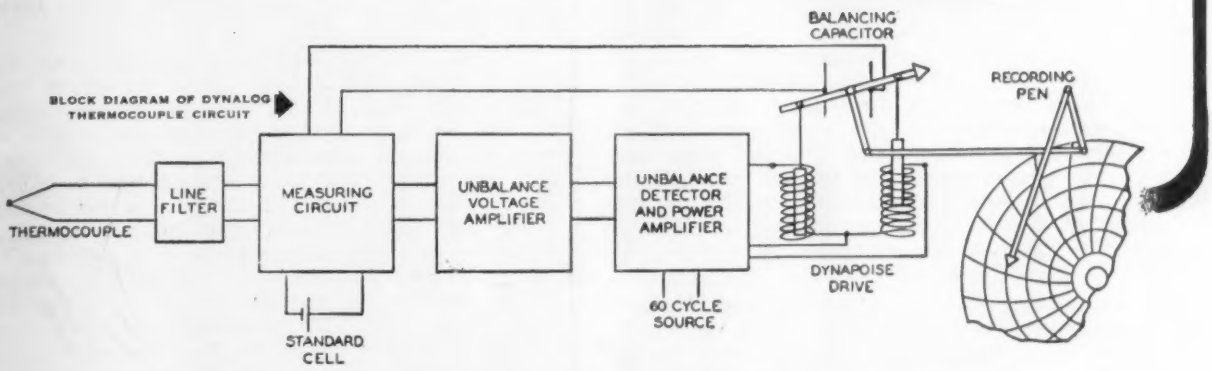

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XII. GAS ADSORPTION APPARTUS FOR MEASURING SURFACE AREAS *(continued)*

Description of the Apparatus *(continued)*

Bath, Furnace and Thermometer

Besides the above-mentioned parts of the system there are three pieces of equipment that are essential; the liquid nitrogen bath which is used to keep the adsorbent at the proper temperature, a sensitive thermometer to measure the temperature of the bath and a furnace suitable for heating the adsorption bulb and sample while it is being evacuated.

Since the bath is to hold liquid nitrogen at −197°C. it is necessary that it be of the Dewar type. It has been found that a 665-cc. wide-mouth "Thermos" jar is the most convenient bath. Liquid nitrogen has a tendency to stratify thermally but a slow stream of nitrogen gas bubbled through the bath will agitate it and keep the temperature uniform. Since the temperature of liquid nitrogen is below the temperature at which oxygen condenses, the oxygen in the air condenses into the liquid causing the temperature to increase slowly. The nitrogen agitator decreases this effect since it keeps a layer of nitrogen gas over the liquid. A loose-fitting cover with holes to admit the adsorption bulb and thermometer is effective in keeping the temperature constant. The tendency of liquid nitrogen to condense oxygen is a potential source of danger. Upon standing the liquid becomes oxygen-rich. In cases where the bath has been used all day and then allowed to stand overnight, the residue which remains the next morning may be almost pure oxygen. Liquid oxygen must of course be kept out of contact with organic materials.

Since P_0, the vapor pressure of nitrogen at the temperature of the adsorption (approx. −195°C.) is needed, it is most conveniently obtained from vapor pressure-temperature tables such as those given by Farkas and Melville[3]. Thus it is necessary to know the temperature of the bath accurately. Since the vapor pressure of nitrogen varies from 922 mm. at −194°C. to 833 mm. at −195°C., in order to know P_0 to the nearest millimeter, the temperature must be known to at least 0.01°C. This can be done with a good thermopile (at least ten junctions) and a potentiometer capable of measuring differences of a microvolt. A less expensive apparatus is an oxygen vapor pressure thermometer. The construction and technique of filling an O_2 thermometer is very well described in Farkas and Melville[3]. A good source of pure oxygen is to fill a 250-cc. bulb one-quarter full of C.P. potassium permanganate and seal it to a 1" tube 10" long filled with glass wool to catch dust and then through a stopcock to the thermometer. This should of course be evacuated with the rest of the system. A brush flame will easily decompose the $KMnO_4$ giving off very pure oxygen. $KMnO_4$ decomposes at 240°C. The thermometer must be mounted in such a way that it can be removed from its position beside the adsorption bulb whenever the adsorption bulb is being degassed in the furnace. A hinged rack or movable stand will accomplish this very conveniently.

The final piece of equipment is a furnace for degassing the sample. Since most porous materials adsorb gases which may be held more or less firmly to the surface, simple evacuation is seldom sufficient to remove all the adsorbed gases. To completely free the surface of all adsorbed molecules may require evacuation for many hours at temperatures of 1400°C. or higher. Fortunately it is seldom necessary to go to such extremes when the surface area is to be determined. Unless a solid has been exposed to organic vapors, adsorbed water vapor is the only substance likely to cause trouble. Heating under vacuum to 150° or 200°C. for an hour is generally sufficient to degas most samples. In cases where the solid has been exposed to organic substances such as chloroform, benzene or acetone, it may be necessary to raise the temperature to 400 or 500°C. The most simple type of furnace to make and use is a glass or ceramic tube of sufficient diameter to fit over the adsorption bulb. This ceramic tube is wound with resistance wire and covered with some insulating material. A "Variac" or other voltage control can be used to adjust the temperature of the furnace.

Surface Area Determination

After the apparatus is assembled it should be completely tested for its capacity to hold a vacuum. It is generally found that a newly-erected system cannot be evacuated to a good vacuum because of adsorbed water vapor on the glass walls of the system. This may be easily removed by heating the glass tubing (being careful not to heat the stopcocks) with a brush flame while the vacuum pumps are in operation.

The next step is to calibrate the free volume of the adsorption system. This is the portion of the system, Fig. 157, between stopcock A, the zero reference of the burette and the zero reference of the manometer. The volumes of the various bulbs are already known by the mercury calibration. To determine the volume of the free space (V_0), with the stopcock A closed and mercury in the manometer, enough gas (either nitrogen or helium) is admitted to the adsorption system to give a pressure of 700 to 800 mm. when the mercury in the burette is at the zero reference. The stopcock to the gas manifold is then closed and the pressure determined with the mercury in the burette on the zero reference. The mercury is then lowered to the No. 1 reference point and the pressure redetermined, this is repeated at the next reference point and so on until all the burette bulbs have been emptied of mercury. We now have a series of pressure readings and we know the total volume of the burettes which were not filled with mercury, V_{tB}, for each pressure reading. Assuming the temperature remained constant during the calibration run and bearing in mind that a constant amount of gas was used throughout we have

$$\begin{aligned} &PV = \text{constant} = K \\ &\text{but } V = V_0 + V_{tB} \\ &\text{hence } PV_0 + PV_{tB} = K \\ &\text{or } PV_{tB} = K - PV_0 \\ &\frac{d\,(PV_{tB})}{dP} = -V_0 \end{aligned} \qquad (33)$$

Hence if we plot PV_{tB} vs. P for each point taken, it should give a straight line the slope of which is the negative of the free volume. Since V_{tB} was corrected to 0°C., V_0 will already be referred to the same temperature. Fig 159 shows such a plot.

We now know the volume of all the parts of the system up to the stopcock A. Rather than having to add up all the volumes each time they are used it is convenient to make a table of the volume of the system for each position of the mercury in the burette. Since the gas in the system will always be corrected to s.t.p. it saves time if these volumes are multiplied by 273.2/760. The resulting set of factors will be called volume factors (f_v). Thus for any amount of gas in the system for which the pressure and temperature have been determined

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$$V \text{ at s.t.p.} = \frac{f_v \times P}{T} \tag{34}$$

where f_v is taken corresponding to the number of burette bulbs used, T is in degrees absolute.

Once the system is calibrated it is ready for actual adsorption measurements. The adsorption bulb is filled with a weighed amount of the solid under investigation and the stopcocks are set so that the entire system including the adsorption bulb will be evacuated. The furnace is put in place surrounding the adsorption bulb and adjusted to the proper temperature. After the degassing has proceeded for at least an hour and the McLeod gage shows the minimum pressure, the furnace is removed and stopcock A closed.

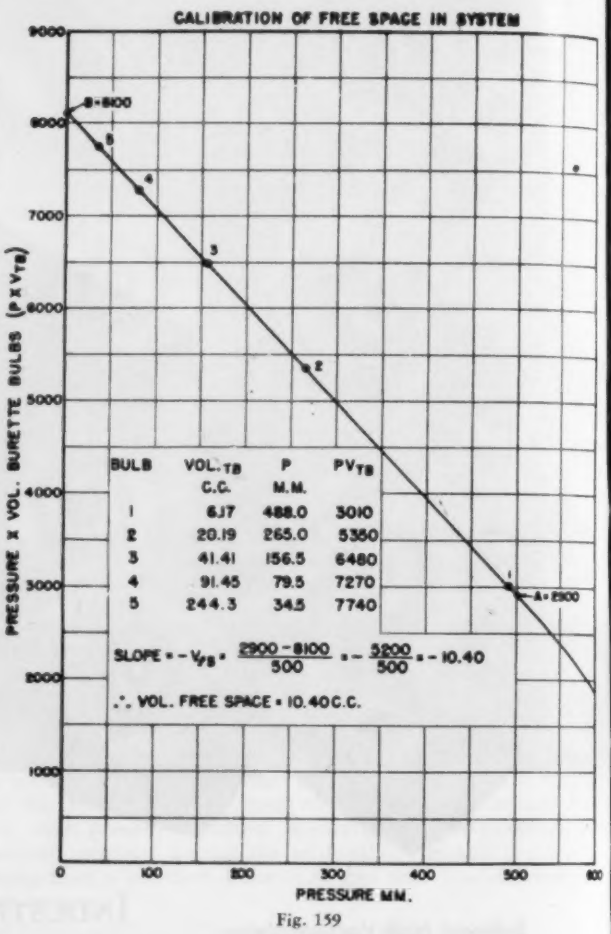

Fig. 159

After cooling, the liquid nitrogen bath is placed in position so that the adsorption bulb is completely immersed in the liquid.

The free volume of the adsorption bulb must of course be determined, i.e., all the space in the adsorption bulb not occupied by the solid. This volume includes the space contained in the pores of the sample. This can only be done by using a gas which is not adsorbed at the low temperatures of the bath. Helium serves the purpose very well.

To obtain this free space a rather large sample of helium is introduced into the burette system with stopcock A still closed. The pressure is measured and the volume of helium is corrected to standard conditions as previously described. This volume is designated as V_T (He). The stopcock A is then opened and the helium admitted to the adsorption bulb. The new pressure P_1 is then determined. From P_1, the temperature of the burette and the corresponding bulb factor the volume of helium remaining in the burette system V_R (He) can be determined. The volume of gas which entered the adsorption bulb when the stopcock was opened is then

$$V_T \text{ (He)} - V_R \text{ (He)} = V_A \text{ (He)} \tag{35}$$

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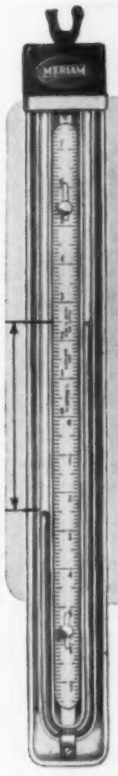

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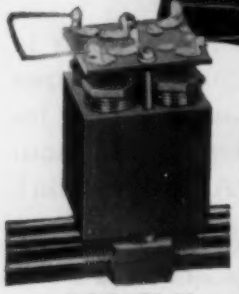

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V_A (He) is of course the volume of the gas at s.t.p. since both V_T and V_R were referred to s.t.p. V_A will of course vary with the pressure P_1. If V_x is designated as the absolute volume of the free space in the adsorption bulb and T_x the temperature of the bath then

$$V_A\ (\text{He}) = \frac{V_x P_1}{T_x} \frac{273.2}{760} \tag{36}$$

or

$$\frac{V_A\ (\text{He})}{P_1} = \frac{V_x}{T_x} \frac{273.2}{760} = \text{constant} = f_A$$

Hence by dividing V_A (He) as obtained in equation (35) by the corresponding pressure a constant is obtained. This constant (f_A) may be termed the adsorption bulb factor. Multiplying f_A by the pressure at any time will give the volume of gas corrected to standard conditions contained in the adsorption bulb. The volumes of all parts of the system are now known and the nitrogen adsorption determinations can now be made.

The helium is first pumped out of the system with the nitrogen bath removed. Stopcock A is then closed and the bath replaced. A dose of nitrogen is then admitted to the burette system and its volume determined in the usual manner. Let this volume be V_T (N_2). The size of V_T (N_2) depends upon the nature and amount of the sample under investigation. The nitrogen is then admitted to the adsorption bulb through the stopcock A. As the gas is adsorbed on the surface the pressure will gradually drop. Sufficient time must be allowed for the adsorption to reach equilibrium. When the pressure has reached a constant value it is recorded. The temperature of the burette must also be recorded and the position of the mercury in the burette. The temperature of the cold bath should be recorded for each reading even though it does not change appreciably. If an oxygen vapor pressure thermometer is being used it should be in place in the bath during the entire experiment. This completes the data necessary to determine the first point.

A second point is obtained by moving the mercury in the burette to the next reference point, thereby decreasing the volume of the system with a corresponding rise in pressure. When the adsorption has again reached equilibrium at this new pressure, the data are recorded and the process repeated until the burette has been completely filled with mercury.

To calculate the volume of gas adsorbed, we know V_T (N_2) and P, T and volume factor (f_v) for each point taken. We also know P_0, the vapor pressure of nitrogen at the bath temperature.

V_T (N_2) = total volume of nitrogen taken

V_R (N_2) = volume of nitrogen remaining in the burette system up to stopcock $A = (P \times f_v)/T$

V_A (N_2) = volume of nitrogen in the free space of the adsorption bulb corrected to s.t.p. $= f_A \times P$. Hence the volume of gas adsorbed V_{Ads} is the difference between the amount taken V_T and the amount remaining in the gas phase $V_R + V_A$, that is

$$V_{Ads} = V_T - (V_R + V_A) \tag{37}$$

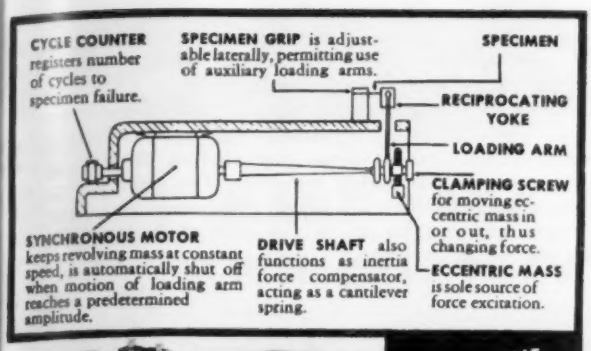
Equation (37) assumes that nitrogen obeys the ideal gas law. Actually it does not and so a correction must be made to equation (37). This correction can be easily applied by multiplying V_A by $1 + (\alpha P/760)$ where α is a constant depending upon the temperature and the gas used. For nitrogen at $-195°$C. α is 0.05. For other gases and temperatures Emmett and Brunauer[4] have listed values of α.

In the plot of the adsorption isotherm it should be noted that the volume adsorbed is plotted against the relative pressure. The relative pressure is simply P/P_0.

Having calculated the volume adsorbed for each of the points taken the total surface area of the sample may now be determined.

Calculation of the Area

As was pointed out with reference to equation (29), a plot of $P/V\ (P_0 - P)$ against P/P_0 should give a straight line whenever equation (28) is a valid equation for the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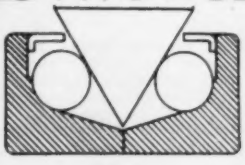

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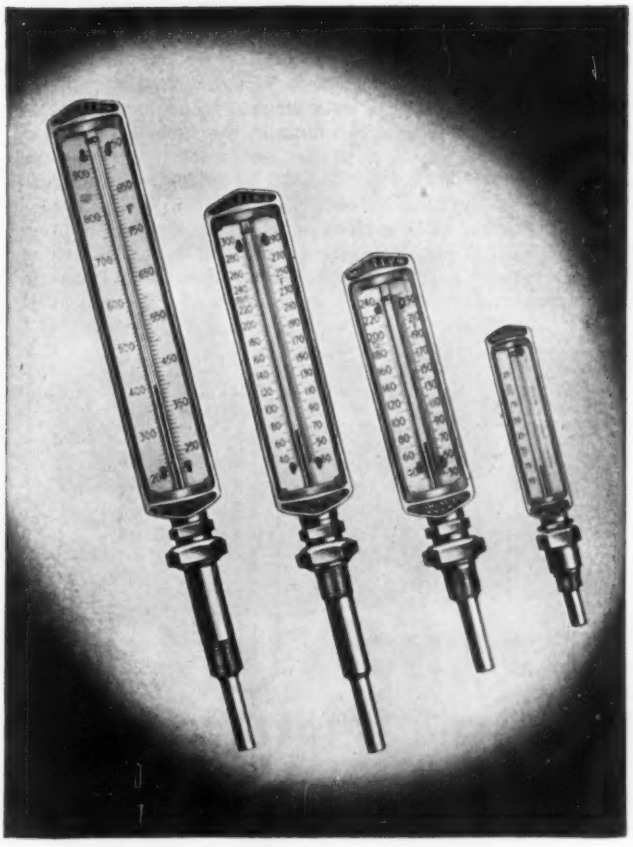

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isotherm. It has been found from the examination of a great many "S" shaped isotherms that equation (28) does fit the data and hence a plot of equation (29) is linear over the relative pressure range 0.05 to 0.3 or higher. Below and above these limits the data deviate from linearity. The procedure then is to plot the data in the form of equation (29) and select the best linear portion. From the slope and interception of this line V_m can be determined by equation (31) and the area by equation (32).

Since equation (29) seldom holds above a relative pressure of 0.35 it is not necessary to plot the data obtained at higher pressures and unless one is interested in the isotherm for purposes other than the calculation of the area it is not necessary to obtain data above this point. It may be noted that

$$\frac{P}{V\,(P_0 - P)} = \frac{P/P_0}{V\,(1 - P/P_0)}$$

which is a more simple function to calculate since P/P_0 must be calculated anyway for the right side of equation (29).

Various Refinements

Having described the essential features of a gas adsorption apparatus and discussed its operation, we will now describe certain improvements which, although not essential, will increase either the accuracy of the data or the ease of operation of the apparatus.

Since any impurity occurring in either the nitrogen or helium gas used in the apparatus may seriously affect the results, purification of these gases before they are stored in the reservoirs is highly desirable. The most serious impurities that are likely to occur in ordinary tank gases are moisture and oxygen or, in the case of helium, nitrogen may also be an impurity.

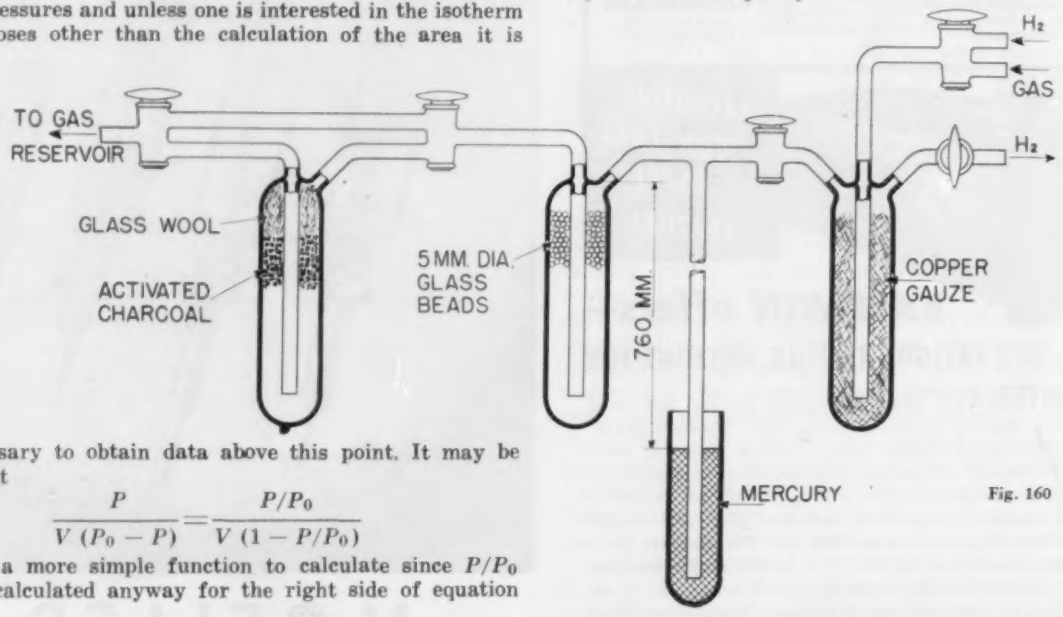

Fig. 160

Passing the gas over reduced copper at about 350°C. will remove all but the last few hundredths of a percent of the oxygen*. A trap filled with glass beads and cooled in liquid nitrogen makes a very effective drying tube. All gases but the inert gases may be removed from helium by passing it over activated charcoal also cooled to liquid nitrogen temperatures. A simple flow system which may be attached permanently to the gas inlet tube (see Fig. 157) is shown in Fig. 160. This arrangement permits all parts of the gas train to be evacuated before the gas is introduced. The depth of the relief tube in the mercury regulates the maximum pressure at which the gas may be stored in the reservoir.

To be continued

*In spite of the statement in most books on the subject hot reduced copper will not reduce the oxygen content of a gas below about 0.05%. In fact it is extremely difficult to obtain nitrogen completely free of oxygen. Where the matter is critical, lamp grade nitrogen such as is used for filling incandescent lamps should be used. Ref. Exline, Kramer and Bowman; *Journal Institute of Petroleum*, Vol. 29, 1943, page 301.

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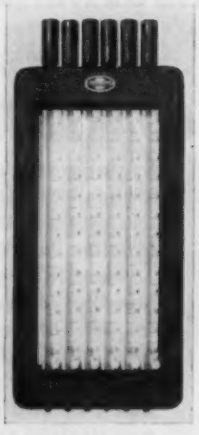
3. Farkas and Melville, Experimental Methods in Gas Reactions, McMillan Company (London), 1939, page 104.
4. P. H. Emmett, S. Brunauer, *Journal of the American Chemical Society*, Vol. 59, 1937, page 1553.

Here's a multiple tube manometer that takes up 30% less space



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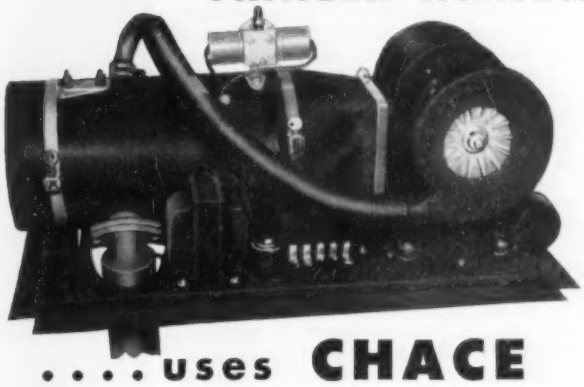

. . . . uses CHACE Thermostatic Bimetal

This miniature central heating plant provides *automatic* heat control to owners and manufacturers of trailers. The compact and efficient unit delivers 14,000 BTU per hour, ample for the coldest days. The even heat flow is maintained automatically by a quiet, high-powered blower which forces heated air through ducts, furnishing constant, even warmth from floor to ceiling.

The South Wind Model 977-D Trailer Heater operates on 110 volt AC circuit, burns vaporized gasoline. The combustion chamber is stainless steel, hermetically sealed for clean, odorless operation with complete safety. An automatic thermostatic control, in which Chace Thermostatic Bimetal is the actuating element, regulates the heat output to achieve a steady desired temperature. Then, too, the automatic overheat switch, an important safety factor in South Wind Trailer Heaters, based on the reliable action of Chace Thermostatic Bimetal, is precision manufactured for unfailing dependability and accuracy. Chace Thermostatic Bimetal is available in sheets, strips or finished forms for many types of temperature responsive devices.

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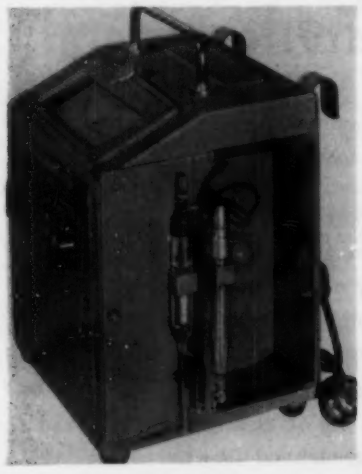
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 581.

Direct-reading pH Meter

New "Industrial Model" line-operated direct-reading pH Meter, designed and built for production as well as laboratory applications, is conveniently portable (weight 10 lbs.) for making spot checks of sample solutions. Case dimensions, 7" × 8½" × 11¼". For continuous process indication, hooks on back of case permit installation over a vat, hanging from a rack, or wall mounting; and special length lead wires can be furnished to permit remote installation. For usual tests of small samples, electrode assembly is mounted on inner side of a compartment door, protected from damage when meter is carried. Completely shielded glass electrode can be used directly in grounded solutions.



Only two simple operating adjustments are needed for standardization. Extremely high stability is said to have been obtained by improved design of electronic circuit and of galvanometer movement: recalibration seldom required oftener than once a week. Compensation is automatic for variations in solution temperature from 0° to 100°C. and for changes in ambient temperature; a voltage regulator corrects for a-c. line fluctuations from 100 to 130 volts. Inclined scale facilitates easy reading. Operation being simple, an unskilled production worker can make quick and accurate pH determinations. —*Cambridge Instrument Co., Inc., 3742 Grand Central Terminal, New York 17, N. Y.*

Please mention number 601 when filling out card

Ultrasensitive Electrical Tester

New "Beckman UltrOHMeter" is for precision measurements of unusually small currents and high resistances. Current sensitivity to as low as 2×10^{-13} ampere full-scale permits resistances as high as 10^{16} ohms to be measured directly. Announcement states that "it is no longer necessary to extrapolate from high-voltage tests." Built-in standard voltage source for resistance measurements provides steps from 0.5 to 20 volts and instrument is so designed that resistor linearity tests and polarization checks can be made conveniently. By use of voltage feedback, time response of instrument is maintained at approx. 2 seconds despite use of input resistors varying from 10^6 to 10^{11} ohms. "UltrOHMeter" can also be used as a high-impedance d-c. voltmeter with sensitivities from 20 mv. to 5 volts with a maximum of 10^{11} ohms input impedance. Other features: Internal resistor calibration means, 23 ranges, minimum current sensitivity of 5 microamperes, minimum resistance of 100,000 ohms, instrument completely battery-operated.—*National Technical Laboratories, 820 Mission St., South Pasadena, Calif.*

Please mention number 602 when filling out card

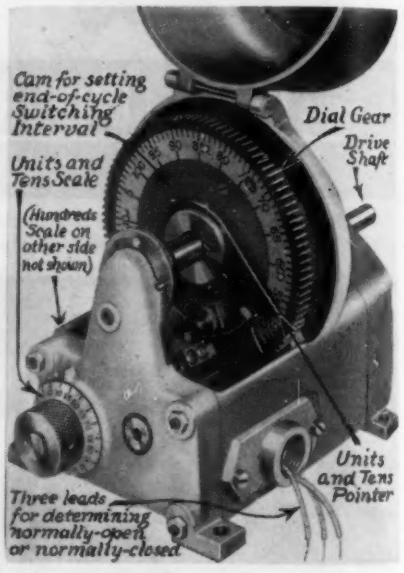
Frequency Meter

New "Model MJ-9 Amateur Frequency Meter" is designed for checking frequencies of FM or AM amateur transmitters operating in any band from 3.5 to 148 Mc. Bands covered are 3.5-4.0, 7.0-7.3, 14.0-14.4, 20.5-21.5, 28.0-29.7, 50-54 and 144-148 Mc. A 500-kc. crystal-controlled oscillator is used as a reference standard. Over-all accuracy, 0.05% at all frequencies. "Model MJ-9" may be used with a following class A amplifier as a substitute for crystal oscillator in an amateur transmitter to provide variable-frequency operation.—Dimensions, 7" × 10" × 6½"; weight, 7½ lbs.—*Browning Laboratories, Inc., Winchester, Mass.*

Please mention number 603 when filling out card

Automatic Process-cycle Controller

New "Cyclo-Monitor" is a process-program controller which opens and closes circuits on the basis of pre-determined counts of strokes or revolutions


Cam for setting end-of-cycle Switching Interval
Dial Gear
Drive Shaft
Units and Tens Scale
(Hundreds Scale on other side not shown)
Units and Tens Pointer
Three leads for determining normally-open or normally-closed

(not time intervals unless process drive is synchronized with standard a-c. time). "Model CMR" is for revolutions and performs equally well in either direction; "Model CMS" differs only in that it is furnished with a short lever for stroke actuation. Each provides a two-part control cycle which may be repeated indefinitely: first part "on" (or "off") during which main dial gear turns in one direction; and second part "off" (or "on"), known as "switching interval," during which main dial gear turns in opposite direction. Maximum of cycle count is 4,000; maximum "switching interval" is 20 units and minimum one-half unit. Switch rating, 125-v. 10-a., 250-v. 5-a., 460-v. 3-a.—*Counter and Control Corp., 2737 S. 28th St., Milwaukee 7, Wis.*

Please mention number 604 when filling out card

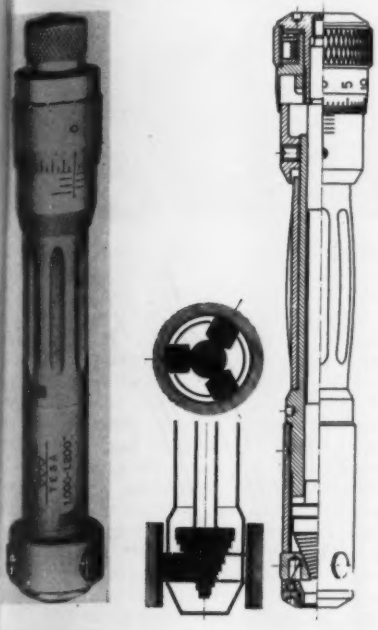
Small Tubular Capacitors

New "68P" and "69P" "Midget" (trademark) paper dielectric capacitors operate at 85°C., have ample humidity protection for normal radio and other uses, embody new materials and processes resulting from maker's engineering of small capacitors for the proximity fuse and other miniature wartime assemblies, meet proposed RMA humidity and voltage tests. Type "69P" capacitors have side leads to allow wiring them across sockets of miniature tubes; "68P" units have conventional end leads.—*Sprague Electric Company, North Adams, Mass.*

Please mention number 605 when filling out card

Internal Micrometer

New "Imicro" Swiss internal micrometer employs three-point measuring principle, allows direct reading to 0.0005" and distance between graduations enables interpolation. Centrally-supported rotatable measuring spindle ends in tapered thread which pushes outwards three feeler bolts lying in a plane perpendicular to axis, until they

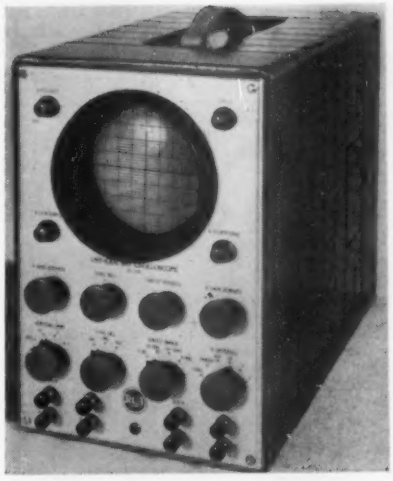


come into contact with wall of bore. For best possible centering, feelers are located at 120°. Uniform pressure is obtained by ratchet which also produces slight vibrations allowing instrument to adjust itself in hole to be measured. Standard set comprises enough inside micrometers to cover total measuring range of set. Set "No. 1092," range 0.5"-0.8" (3 instruments); "No. 1093," 0.8"-1.6" (4 inst.); "No. 1094," 1.6"-4.0" (6 inst.).—*Maveg Machine Sales Ass'n, Inc., 24-16 Bridge Plaza South, Long Island City 1, N. Y.*

Please mention number 606 when filling out card

Interchangeable Plug-in-tube Cathode-ray Oscilloscope

New "Type WO-60C" portable cathode-ray oscilloscope, first to permit quick interchange of three different types of cathode-ray tubes, is a general-purpose instrument built rugged for

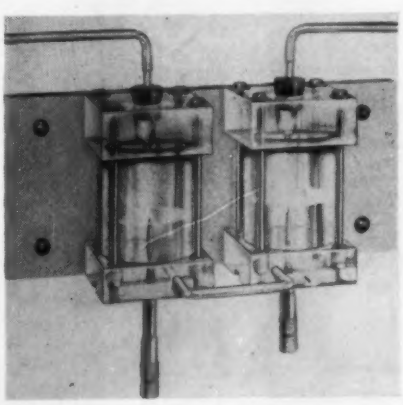


industrial applications. It handles input voltages as high as 850 volts peak to peak, permits observation of waveforms of 0.5 to 300,000 cps. Furnished with "WO-60C" is a medium-persistence cathode-ray tube for general applications. For lowest frequencies, a long-persistence flickerless screen is desirable. A third tube, having a short-persistence highly-actinic screen, is best for photographic recording without blurring. Latter two tubes are available as accessories. Changeover from one tube to another takes as little as ten seconds, is accomplished by detaching light shield, removing tube and plugging-in another. New oscilloscope is self-contained, weighs 31 lbs. It comprises high-gain amplifiers, calibrated attenuators, oscillators, and internal high- and low-voltage power supplies. Regulator tubes stabilize critical voltages. Horizontal and vertical amplifiers have practically identical electrical characteristics, special cathode-coupled input stages giving low-capacitance high-impedance input, permitting rapid change of gain without surges and preventing signal from shifting or leaving screen. This stability aids visual examination and especially photographic recording. Gain is manually adjustable without distorting wave-shape or altering frequency or phase characteristics. —*Test and Measuring Equipment Section, RCA Victor Division, Camden, N. J.*

Please mention number 607 when filling out card

Precision Hook Gage

New "Dwyer Transparent Hook Gage" is said to exceed in accuracy any in its class yet invented, utilizes prin-



ciple of water-column U-gage. Capillarity effect ordinarily encountered in gages of this type has been overcome by widening columns to 2½". Measurements are taken from center of column by hooks attached to depth micrometers of a standard make, reading to 0.0005" over a 2" range. Manufacturer explains that use of standardized parts keeps instrument in moderate-price field and permits added uniformity and dependability. Except for hooks and micrometers, gage is made of an unbreakable transparent plastic, may thus be read easily and its operation checked at a glance. Provision has been made for rapid disassembly and cleaning. Principal use of precision hook gage will be checking other instruments; also for measuring any steady pressure within its scale range to 0.0005" water column.—*F. W. Dwyer Mfg. Co., 317 South Western Ave., Chicago, Ill.*

Please mention number 608 when filling out card

Analyzer for Electrical and Electronic Apparatus

New "Model 769 Electronic Analyzer" provides facilities for voltage, current and resistance measurements covering

frequency ranges of practically all present electronic applications. It comprises a completely stable high-frequency VTVM for measurements on frequencies up to 300 Mc., an electronic volt-ohmmeter, and a complete 10,000-ohm-per-volt d-c. and 1000-ohm-per-volt a-c. multimeter. Use of a new type unity-gain d-c. amplifier, incorporating both regeneration and degeneration, achieves remarkable stability of VTVM and volt-ohmmeter circuits. "Model 769" is completely line isolated and line insulated to reduce external r-f. influence. R-f. probe, equipped with a flexible cable for plugging into front panel, is of Bakelite and Polystyrene construction with a minimum exposed metallic area, and completely isolated from any d-c. potential influence. Analyzer section provides complete versatility of measurement: six 10,000-ohms-per-volt voltage ranges, six rectifier type a-c. voltage ranges to 1200 volts, three ohmmeter ranges to 200,000 ohms, and six d-c. ranges to 600 ma. A special d-c. probe containing a 5-megohm resistor measures d-c. potentials with minimal insertion effect. Standard test leads also are provided. Power supply is self-contained; no external a-c. supply is required when using "Model 769" as a

STATHAM WEIGHING RINGS

Remote indication or recording of large forces is easily accomplished with Statham Weighing Rings. Made to suit your particular requirements, they may be had in ranges to 10,000 pounds. A variety of connections may be specified to permit use of the Rings in tension, compression, or both. Their output is sufficient for direct operation of simple D-C meters, or of high speed recording galvanometers or oscillographs without the need for expensive electronic equipment.

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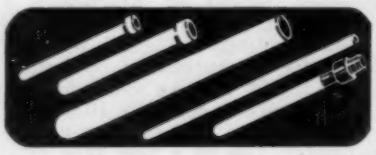

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standard analyzer. Solid oak case, 10″ × 13″ × 6⅛″.—*Weston Electrical Instrument Corp., Newark 11, N. J.*

Please mention number 609 when filling out card

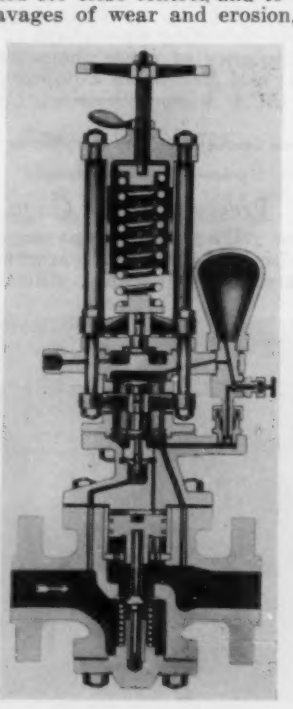
Volt-ohm-ammeter

New "Type WV-65A Battery Volt-Ohmyst," is a self-contained lightweight vacuum-tube voltmeter operating independently of any external power source, so that it can be used for servicing equipment in automobiles, airplanes, boats, in rural areas, in industrial electronic applications, etc. It incorporates best features of maker's conventional model "VoltOhmyst," measures 9⅝″ high × 6¾″ wide × 6¾″ deep; has five a-c. and six d-c. voltage ranges to 1000 volts, six ohmmeter ranges to 1000 megohms and six ammeter ranges to 10 amperes.—*Test and Measuring Equipment Section, RCA Victor Division, Camden, N. J.*

Please mention number 610 when filling out card

Pump Governor

New line of pump governors, specially designed for close control and to resist the ravages of wear and erosion, feature hard-surfaced seat rings, 80 Brinell hardened stainless steel main valve and 500 Brinell cylinder liner. Other design features include wide spring range which permits setting without change of spring or diaphragm, single-seated valve, no packing or stuffing boxes, interchangeability of replacement parts without removal of the body from the line. Available in sizes from ½″ to 4″ for inlet pressures from 40 to 600 lbs./in.² at temperatures to 750°F.—*Leslie Co., 225 Delafield Ave., Lyndhurst, N. J.*



Please mention number 611 when filling out card

Automatic Gage and Sorter

New "Model DS-20 Selector" is an automatic inspector-segregator for sorting small parts into three classifications: oversize, acceptable and undersize. Accurate to 0.000,01″, "Selector" will sort parts with tolerances from ±0.0001″ to ±0.005″ at speeds up to 12,000 parts per hour. It comprises three units; gage head, master control and segregator. It is said that because of unique electric circuit, speed of operation is limited only by feeding-rate of parts. Fully-automatic and semi-automatic feed mechanisms are available. "Model DS-20" comes as a "packaged unit" ready for operation. By using gage blocks it can be set in a few minutes. Master control unit has red and green indicating lights, also an electric gage which provides visible readings of size of each part being sorted, and which is sealed against dust and moisture. Available accessories: (1) an electrical counter for counting acceptables and rejects; (2) a hearing aid which makes possible efficient operation of "Selector" by a blind person. "Selector" can also be adapted for measuring internal dimensions, for simultaneous checking of more than one dimension, or for sorting into more than three classifications. Besides "Model DS-20," three other "packaged units" are available.—*DoAll Co., 1301 Washington Ave. South, Minneapolis 4, Minn.*

Please mention number 612 when filling out card

Voltage Regulator

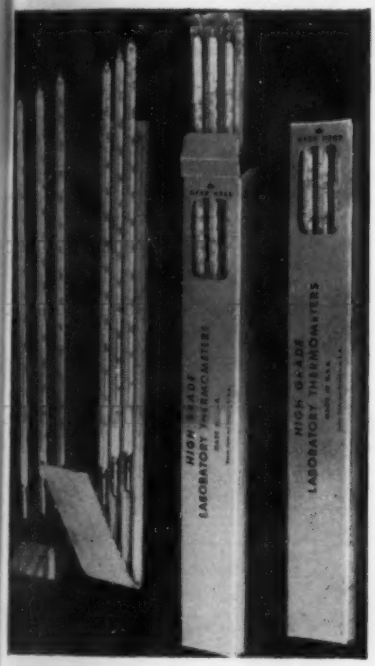
New "Stabiline Type IE" (Instantaneous Electronic) voltage regulator is said to provide instantaneous correction of line voltage fluctuations with negligible wave-form distortion. Output voltage is held to within ±0.1 volt of any set value between 110 to 120 volts for an input line voltage change from 135

95 volts. Time for recovery depends on line voltage, load current, load power factor and other conditions, but usually is 3 to 6 cycles. Performance is not affected by any load change from zero to full rating of unit, is independent of any load power factor change from 0.5 lagging to 0.9 leading. Wave-form distortion under all adverse conditions never exceeds 3% and for most operating conditions is between 1% and 2%.—*The Superior Electric Co., 531 Laurel St., Bristol, Conn.*

Please mention number 613 when filling out card

Laboratory Thermometer Sets

New sets of three laboratory thermometers come in an entirely new shipping carton said to save half the weight



and half the volume of conventional methods and provide greater shipping and storage protection. Another advantage is that window in outer container facilitates stock recording without opening.—*H-B Instrument Co., Inc., 2518 North Broad St., Philadelphia 32, Pa.*

Please mention number 614 when filling out card

Photoelectric Densitometer

New "Precision Densitometer" supersedes maker's previous models, is said to permit exact determination of light transmission through photographic negatives and other semi-opaque objects, and to be especially suited to requirements of photographers, lithographers, and laboratories requiring absolute precision in their work. New color printing

This is truly a practical D. C. amplifier! It opens new uses for your Brush Direct-Inking Oscillograph. As with all Brush products this new instrument represents years of intensive research in engineering and design. Write today for the complete story . . . Brush representatives will be glad to demonstrate.

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- **Calibration Circuit**—for convenient determination of input signal levels
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- **Power Requirements**—115 volts, 60 cycles
- **Portability**—Weight 30 pounds

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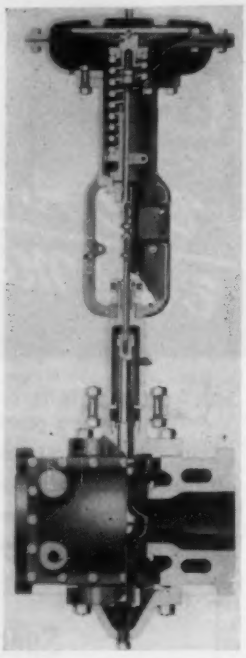
methods require such precision. Range of negative densities, 0 to 3.0 with uniform scale and sensitivity and with readings to less than 0.005 density units. Smooth top offers ample space for large negatives. A ¾″ illuminated finder disk which makes it a simple matter to locate exact area in negative: when pick-up arm is lowered, finder disk goes dark and measuring beam of light is only 1/16″ in diameter. Operation is simple. Density is read directly. Balanced vacuum photocells give stability and eliminate line voltage effects. Densitometer weighs 15 lbs., measures 14″ × 14″ × 8″ high; operates on a.c.—*National Photocolor Corp., 305 East 43rd St., New York 17, N. Y.*

Please mention number 615 when filling out card

Diaphragm-motor Valve

New "No. 700 B" packless bellows-sealed diaphragm-motor valve is designed for service where it is impera-

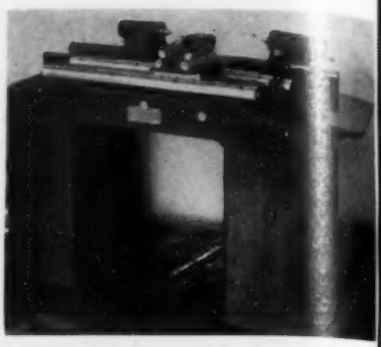


tive to avoid leakage of the controlled fluid. Bellows-seal assembly has been designed as an integral unit which can be easily detached from valve stem without disassembly of valve body. Operating conditions and nature of flowing fluid determine selection of bellows material. For highly viscous fluids, steam-jacketed bodies, with or without steam-jacketed bellows and radiation fins, are available upon specifications.—*H. Belfield Co., Broad St. at Hamilton, Philadelphia 23, Penna.*

Please mention number 616 when filling out card

Thread-lead Tester

New "Model C Electro-Mechanical Lead Tester" takes workpieces up to 10″ in diameter and 30″ long between tailstock centers. Work longer than 30″, ranging from ½″ to 3″ in diameter, can be checked easily using V-block work supports. Measuring head is a P&W Supermicrometer Headstock with a 1″ spindle travel. Spindle is graduated in increments of 0.050″. Dial has 50 graduations of 0.001″ each, with a vernier to 0.0001″. Thread locating head is an

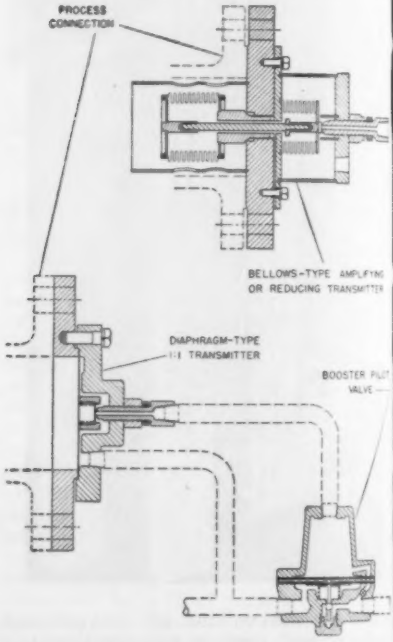


"Electrolimit" universal circuit hea with ball point holder and ball point Cross slide, which carries thread locat ing head, is a spring-loaded devic which gives correct gaging pressure o ball point when centered in thread, re gardless of work diameter and pitch Carriage is equipped with a counter weight which keeps pressure agains end measures and measuring head con stant.—*Pratt & Whitney Div., NB West Hartford 1, Conn.*

Please mention number 617 when filling out card

Pressure Transmitters

New amplifying and reducing model of "Nullmatic" pressure transmitter for liquid level and pressure applications are announced. Bellows-type in-



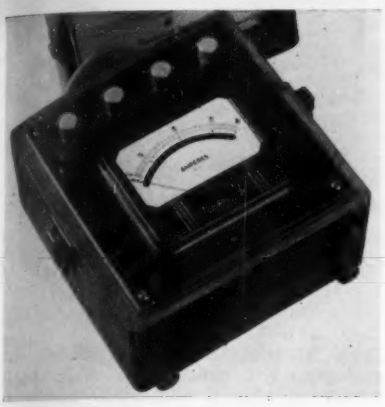
struments are designed to measure process pressures in ranges as small as 1 lbs./in.² or as large as 200 lbs./in.² and to transmit a range of air pressures which suit standard pneumatic receivers. Diaphragm-type instruments measure process pressures up to 60 lbs./in.² and transmit air pressures in a 1:1 ratio. All transmitters operate on pneumatic null balance principle as shown in diagram: booster pilot maintains a constant differential pressure across pilot nozzle in transmitter, to balance bellows or diaphragm at essentially a "null" position for all values of process pressure. This pneumatic force-balance operation is said to result in high-speed linear transmission. High

overload protection is provided. Corrosion-resistant materials are available. All units can be furnished for mounting on standard flanges or provided with a pressure chamber.—*Moore Products Co., H & Lycoming Streets, Philadelphia 24, Pa.*

Please mention number 618 when filling out card

Portable Electrical Instruments

New "Model 77-M" portable a-c. voltmeters, ammeters, single-phase and polyphase wattmeters, etc., operate on

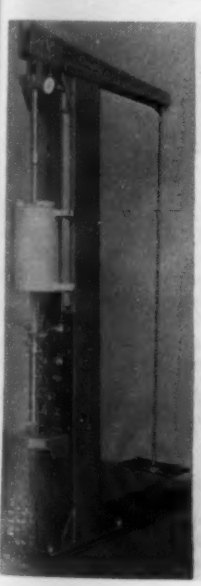


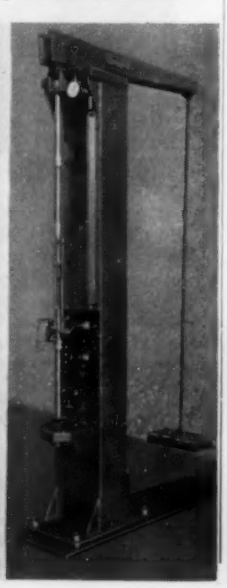
electrodynamic principle, have knife-edge pointers and 3½" mirror scale, magnetic damping and other refinements. Accuracy is 0.75% of full-scale value. Dimensions, 8" × 8" × 5¾" (polyphase wattmeter 8" × 8" × 7¼"). Some instruments are triple-range. Shunts, transformers and other high-grade accessories are available. New instruments, now available separately in mahogany cases, have heretofore been components of maker's "Electrical Power Analyzer."—*Niagara Electrical Instrument Co., 559 Ellicott St., Buffalo 3, N. Y.*

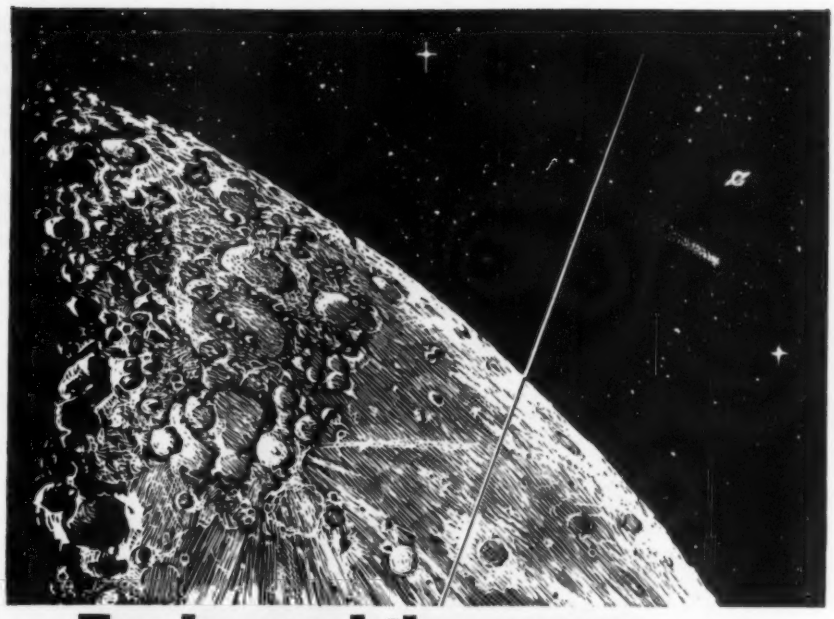
Please mention number 619 when filling out card

Creep-test Apparatus

New creep testing machine is of lever arm type, 12,000-lb. capacity, accuracy guarantee within 1% of load. Strain indication is by extensometer, is read directly to 0.000025" on a motor-driven revolution counter by means of a follow-







Far beyond the moon...

Hathaway Type S12-A 12-element Portable Oscillograph
• Very small • Automatic • Simple to operate

ONE OF A COMPLETE LINE OF RECORDING OSCILLOGRAPHS AND HIGH-SPEED GRAPHIC INSTRUMENTS

Men talk of trips to the moon nowadays but science has already travelled far beyond in its search for truth . . . from inconceivable distances come faint glimmerings that reveal secrets of distant universes.

Just as these messages from space are interpreted by MEASUREMENTS, so has every scientific discovery resulted from our ability to build and to use ACCURATE MEASURING INSTRUMENTS.

To keep abreast with the ever-changing needs of modern research, Hathaway engineers are constantly working on new measuring instruments, constantly improving older ones. Whatever may be YOUR new problem in MEASUREMENT OR CONTROL, Hathaway experience can help you.

WRITE FOR TECHNICAL BULLETIN SP-167B

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO

Automatic
ELECTRIC PRODUCTS

TIME SWITCHES
Ruggedly constructed *Automatic* Switches have visible dial in tamper proof compact cabinet . . . pure silver contacts . . . 2 to 24 "on" and "off" operations. For any load . . . for every installation an *Automatic* time switch or Interval Timer will deliver superior performance.

Synchronous or Manually Wound

FLASHERS
Automatic heavy duty, motor driven Flashers available in circuit arrangements for every conceivable effect. Pure silver contacts. Models for any load or purpose.

Alternates *Chasers* *Spellers*

RELAYS
Automatic manufactures a complete line of dependable relays for industrial, business machines, radio, electronic and many other uses . . . open, or can type with tube-base, plug-in features.

Consult our Engineering Department

WRITE FOR SPECIFICATIONS AND INFORMATION TODAY

In Switches, Flashers and Relays where dependable performance is paramount, look for the "Diamond Seal for Diamond Quality".

WRITE TODAY!

AEMCO
Automatic Electric MFG. CO.
58 STATE ST., MANKATO, MINNESOTA

QUIK-LABELS
CODE CARD SYSTEM

Removable Self-Starter Strip exposes ends of Labels for you to peel!
DON'T PICK. USE SELF-STARTER STRIP TO PEEL LABELS.
FREE SAMPLES
DON'T PICK. USE SELF-STARTER STRIP TO PEEL LABELS.
1 PEEL
2 APPLY
3 IDENTIFY
LIKEWISE ON FLAT SURFACES
*Patents Pending

QUIK-LABELS
Mark Your Wires Faster

QUIK-LABELS code Wires, Leads, Circuits, Relays, Parts, etc., faster and cheaper. • Pre-cut to exact size, QUIK-LABELS come on handy cards. • Ready to use, they stik-quik without moistening, replace slow and costly string tags, roll tapes, decals, stencils, metal tabs, etc. • Silicone plastic coated to resist dirt, grease, abrasion. • *Self Starter Strip automatically exposes ends of Labels for you to grasp instantly—no more finger-picking.

Write for Folder and FREE Sample Cards

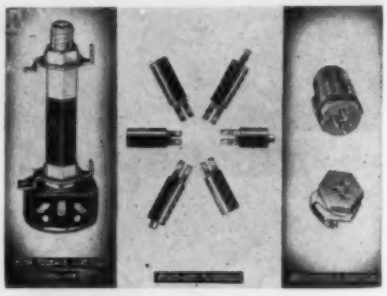
W. H. BRADY COMPANY
Established 1914
Manufacturers of Self-Sticking Tape Products
804 N. 3rd Street, Milwaukee 3, Wisconsin
Factory—Chippewa Falls, Wisconsin

up contact method. Extensometer will operate to rupture. Specimen is heated by a small furnace (see left-hand photo) with Chromel wire coils in three banks to provide temperature adjustment in top, middle and bottom zones by means of rheostats. Standard maximum temperature 1600°F.; 1800 and 2200°F. furnaces can be supplied. Maximum possible elongation of the specimen is 1¾". — *Baldwin Locomotive Works, Philadelphia 42, Penna.*

Please mention number 620 when filling out card

Stand-off Terminals and Connectors

New complete line of small stand-off terminals provide a rugged, well insulated tie-point, or mounting block, in

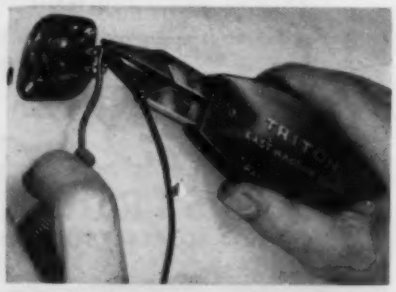


a minimum of space. Molded-in terminals, machined of brass, are silver-plated for rapid, easy soldering. New "High Voltage Control Stand-Off No. 401" (left) fits all standard variable resistors, affords ample insulation to prevent voltage breakdown, eliminates shock hazard, mounts on panels drilled in accordance with RMA standard for variable resistors. Spacing between high voltage and grounded metal parts is 1 3/16". A lock arm prevents rotation of the control with respect to the panel. New 4-contact miniature connectors (right) have been designed for applications where space is extremely limited. One-piece inserts are molded of Melamine. Silver-plated phosphor-bronze sockets insure good contact action.—*The Winchester Co., 6 East 46th St., New York 17, N. Y.*

Please mention number 621 when filling out card

Instrument Soldering Tool

New "Pres-to-Heat" soldering tool operates from a.c., uses a 6-volt transformer and a light-weight heating unit. A spring-actuated lever, when compressed, closes two plier-like carbon electrodes on parts to be soldered. Further compression switches current on for period required to melt solder. Slightly releasing lever turns off current and permits work to be held be-



tween jaws until solder has cooled. Current is consumed only when the actual soldering operation is being performed. —*Triton Mfg. Co., East Haddam, Conn.*

Please mention number 622 when filling out card

Resistor Kit

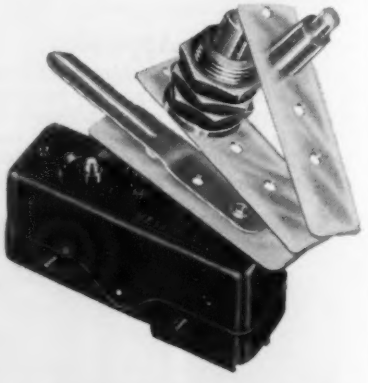
New "Basic Kit" of most-used resistor types and ranges is especially suited for engineering and development

labs, broadcast stations, schools and colleges. Kit consists of 471 "basic" resistors, plus 6 additional bands for adjustable types. No extra charge for cabinet. Resistor assortments are in most cases so arranged that a lack of stock in one range may be compensated for by using two other ranges in series or parallel.—*International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.*

Please mention number 623 when filling out card

Interchangeable Auxiliary Actuators for Snap Switches

New removable and interchangeable actuators for "Unimax" snap-action switch allow basic switch to be adapted

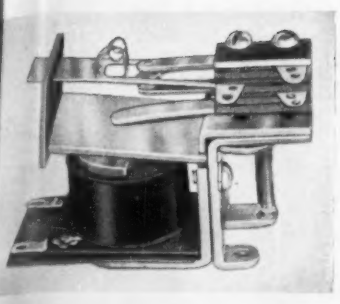


to varied uses with auxiliaries added in factory assembly or to be stocked separately. Actuators are mounted on stainless steel plates, so that a uniform relationship is established between actuators and switch-operating button by fixed dimensions in mounting plate and phenolic housing.—*Unimax Switch Corp. Subs. of W. L. Maxson Corp., 460 West 34th St., New York 1, N. Y.*

Please mention number 624 when filling out card

Snap Switches for Relays

New complete line of snap-action switches is available in conjunction with maker's standard relays. Snap-

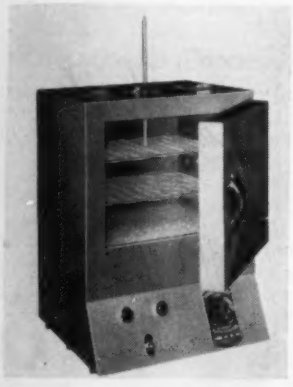


tion feature is particularly suited to ntrol applications that involve slow-oving mechanical devices or where a ven stroke is required to provide ick, positive "make" or "break" con-ct action. It is claimed that chatter-g, arcing, intermittent contact pres-re and other circuit operating prob-ms are eliminated. Illustrated is Series 100 Relay" with a snap-action witch for motor starting circuits (cir-it diagrams available). A snap-ac-on switch relay can be used in place a centrifugal switch normally (and conveniently) installed in motor hous-g. — *Guardian Electric Mfg. Co., ept't SA, 1638 West Walnut St., Chi-go 12, Illinois.*

Please mention number 625 when filling out card

Laboratory Oven

New "KH 1200" electric laboratory n features equalized heat by means a double-venting device. Automatic



hydraulic-electric temperature control feature has accuracy of ± 1°C. at any desired point within furnace range to 220°C. Internal dimensions 12" × 10" × 10"; outside 15⅜" × 21¼" × 15".— *The K. H. Huppert Co., 6830 Cottage Grove Ave., Chicago, Illinois.*

Please mention number 626 when filling out card

Electric Soldering Iron

New "No. 300 Hatchet Type" electric soldering iron enables operator to solder in a more natural position, mini-

Bulletin of the Month

"BRIDGE-MEG" INSULATION and RESISTANCE TESTER

*REG. U. S. PAT. OFF.

DESIGNED and built to provide maintenance men with practically everything necessary for electrical resistance measurements from a fraction of an ohm up to 1000 megohms, the "Bridge-Meg" type of "Megger"* instrument combines in one compact, *portable* unit the facilities of a "Megger" Insulation Tester and a Wheatstone Bridge.

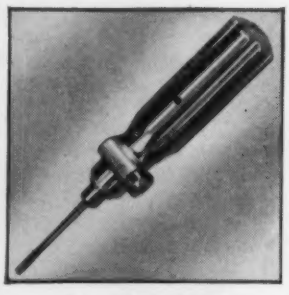
You'll find the "how and why" of the "Bridge-Meg" Insulation and Resistance Tester described fully within the profusely illustrated pages of this Bulletin of the Month. *Your* copy is waiting. No obligation, of course. Send *today* for Bulletin 21-60—IJ.

James G. BIDDLE CO.
ELECTRICAL & SCIENTIFIC INSTRUMENTS
1316 ARCH STREET • PHILADELPHIA 7, PENNA.

New Type of Torque Tools Incorporate Spring Clutch!... Are 98% Accurate!

Acme Torque Wrench and Screw Driver both incorporate spring clutches, with easily operated control. After setting control to desired torque, the operator merely turns tool in the usual way. When the torque required to drive the threaded part exceeds the pre-set value, the tool slips. Impact doesn't cause driving torque to increase. Oil doesn't affect setting which is reproducible within 2% or better.

The Wrench offers right and left-hand drive, ratchet action and withdrawal. Spring clutch may be set from 0 to 500 inch pounds. Standard sockets are interchangeable. The Screw Driver may be set for any value of torque from 0 to 35 inch pounds. A ratchet action is incorporated. The same tool will also withdraw screws. Standard bits, including socket types, may be easily inserted. The tool is made of pressure cast aluminum.



Torque Screw Driver

Another Time-Saver on the job, is chewing gum. The act of chewing aids the workers' concentration—seems to make the work go easier. Chewing gum may be used even when workers' hands are busy; reducing interruptions from the job. For these reasons many plant owners have made Wrigley's Spearmint Gum available to everyone.

You can get complete information from Acme Scientific Company, 1450 W. Randolph St., Chicago 7, Ill.

AB-64

mizing fatigue. Inaccessible spots can be reached without stooping or bending over the work. Heating element is housed in a damage-proof hexagonal shaped barrel that permits clamping in a vise for easy tip removal without danger of injuring heating element. Tips are hard drawn copper; simple to remove. Each iron is furnished with a stand.—*Hexacon Electric Co., 179 West Clay Avenue, Roselle Park, N. J.*

Please mention number 627 when filling out card

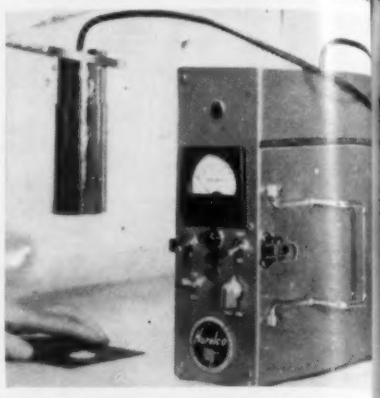
Rapid-indicating Multi-point Potentiometer

New "Speedomax Indicator" is a rapidly-self-balancing potentiometer for applications where a large number of thermocouple temperatures must be logged in a short time. To read a temperature, operator merely flips a key switch marked for desired thermocouple; instrument's drum scale spins and then stops at the correct temperature. When logging temperatures, limiting factor is speed with which operator can write down his readings. Instrument being a true potentiometer, it has high sensitivity and accuracy, even for low temperatures and short ranges. Wide markings make scale easy to read. Switching arrangements can be supplied to meet needs of practically any application. A single instrument easily handles more than 100 thermocouples. Key switches can be color-coded for convenience in identifying points.—*Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia 44, Penna.*

Please mention number 628 when filling out card

Geiger-tube Radiation D tecto

New portable Geiger-counte radiation detector is battery powere is ca ried by hand or by means of a houl

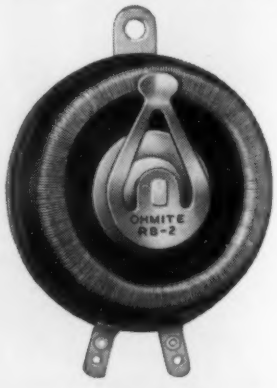


strap. Geiger tube housing permits di ferential detection of hard and s components. Controls and indicators a located on top panel so that adjus ments and measurements can be ma while unit is being carried. Indicat shows rate at which pulses are receiv and also is used to determine potenti applied to Geiger tube. Visual indic tion of pulse rate is provided by flash mounted on panel. Audible signals c be received by head phones. High- a low-voltage supplies switch is inte locked with cover. Metal cabinet mea ures 12¼" × 11¾" × 4¼"; instrume complete with batteries weighs 17 lbs.- *North American Philips Co., Inc., 1 East 42nd Street, New York 17, N.*

Please mention number 629 when filling out card

Direction-indicating Resistor

New "Model RB-2 Direction-Indicat Potentiometer" is said to provide simple method of indicating the positi



of a rotary-beam antenna, wind vane or other rotating device. Its shaft is coupled to antenna and it is connected by means of a simple circuit, to a 6-volt battery and a milliammeter (with specially marked scale) which will indicate position of antenna. Maximum current drain is a few milliamperes.—*Ohmite Mfg. Co., 4855 Flournoy St., Chicago 44, Illinois.*

Please mention number 630 when filling out card

Test Oscillator

New "Type WR-67A Test Oscillator" is a portable test unit designed with special features to aid servicemen in rapid aligning and trouble shooting of

radio and broadcast equipment. It operates from 100 kc. to 30 Mc.—*Test and Measuring Equipment Sec., RCA Victor Div., Camden, N. J.*

Please mention number 631 when filling out card

Sweep Generator

New "Type WR-53A Sweep Generator" is designed for FM receiver alignment. It is used in the alignment of i-f. transformers in the 9.5 to 11.5 Mc. range; is also used to align the r-f. stages of FM circuits in the 88 to 108 Mc. range.—*Test and Measuring Equipment Sec., RCA Victor Div., Camden, N. J.*

Please mention number 632 when filling out card

Cabinet for Multipoint Gas Alarm

New "Multipoint Alarm Cabinet" for detection of combustible gas concentration occupies 2 2/3 ft.^{2} of floor area. It is available for sampling from a minimum of 6 locations to a maximum of 12 locations. Cabinet is composed of a series of panels as illustrated. On top panel are mounted indicator, motor, main switch, alarm relays and push button controls; other 7 panels are connected to individual analyzing heads; in base is mounted a sampling pump which continuously draws samples through all analyzing heads. Each analyzer panel is consecutively connected with top panel for ten seconds. Thus, if six areas are being sampled, a complete tour can be made in one minute. During connection a white pilot light flashes on analyzer panel to show that gas percent in the area being tested can be read on indicator. When concentration reaches alarm point setting, a red pilot light flashes on corresponding panel; and an audible signal sounds both in cabinet and in area. Provision has been made for stopping timer to hold a panel for further observation. On top panel are mounted push button controls for silencing audible signals and extinguishing red alarm lights on individual analyzing panels. New system may be connected to relays which will actuate CO_2 or fog fire blanketing systems.—*Davis Emergency Equipment Co. Inc., 80 Halleck St., Newark 4, N. J.*

Please mention number 633 when filling out card

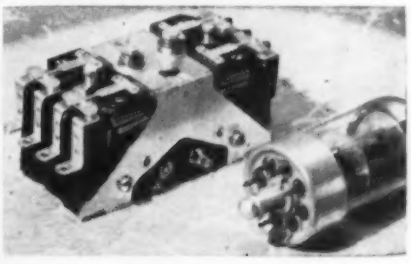
Dry Electrolytic Capacitors

New "Type LB" miniature dry electrolytic capacitors embody "new method of producing unprecedentedly high-gain and stable etched foil." Availability of new units is said to free circuit designers from space limitations. Capacitance values available for low ripple service in a ⅜" × 1⅛" container range from 8 mf. at 150 wvdc. to 200 mf. at 1.5 wvdc.; in a ⅜" × 1⅝" tube maximum capacitances range from 12 mf. at 150 wvdc. to 300 mf. at 1.5 wvdc. Maximum a-c. ripple voltage which may be applied to capacitors rated at 100 wvdc. and greater is 7 volts at 60 cycles or 3.5 volts at 120 cycles.—*Solar Mfg. Corp., 285 Madison Avenue, New York 17, N. Y.*

Please mention number 634 when filling out card

Latching Relays

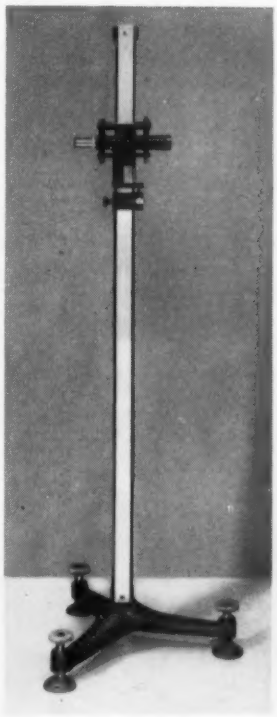
New "Type 6FZ" multi-circuit switching relays of latching type have entire moving system dynamically balanced, while operating with detent forces of over 200 inch-grams, achieving exceptional freedom from effects of vibration and shock. Mechanical wear does not lessen, but, if anything, increases latching stability, resulting in a mechanical life well up into millions of operations, it is said. Each of eight individual switch positions may be normally open or normally closed, nominal rating 5 amperes at 110 volts a.c. or 24 volts d.c. Contacts may be ganged or arranged in pairs for a maximum of 4 double-break circuits as illustrated. Coils operate from d.c. (or rectified a.c. supplied from a single midget sele-



Gaertner

M907-M908

CATHETOMETERS

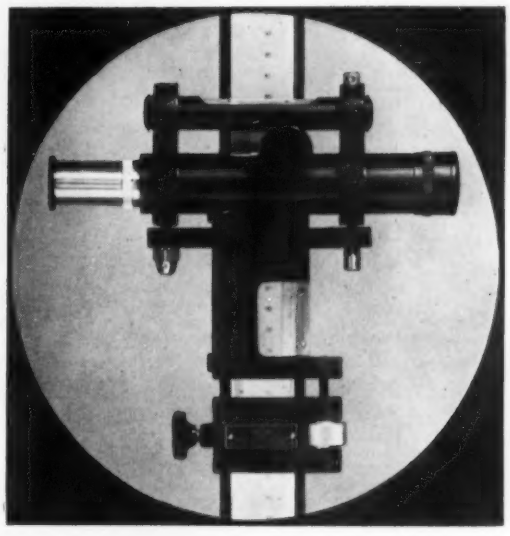


For vertical measurements on objects located near sources of dangerous radiation, within controlled atmosphere enclosures, or otherwise inaccessible.

Range of Measurement

M907 ..... 60 cm
M908 ..... 100 cm

The carriage slides on an accurately straight guide rod and is provided with delicate height adjustment. The scale may be read by vernier to 0.05 mm. Working distance is from 60 cm to infinity.



Complete details on these and more than a dozen other types and sizes of cathetometers will be found in Catalog M138.

THE GAERTNER SCIENTIFIC CORP.
1211 WRIGHTWOOD AVE. · CHICAGO 14 · U.S.A.

Speedy • Accurate

RESISTANCE MEASUREMENTS

. . . with the Rubicon
PORTABLE WHEATSTONE BRIDGE

This convenient instrument combines instant portability with high accuracy and is widely used in laboratory, plant and field. Built for dependable service under hard usage.

- Wide range: 1 ohm to 10 megohms
- Limit of error: 0.1%
- Built-in battery and galvanometer
- Provision for external battery and galvanometer when required
- Available with Murray and Varley loop circuits
- Compact and rugged

. . . with the Rubicon
PORTABLE KELVIN BRIDGE

For work at very low resistance levels this instrument is the counterpart of the Wheatstone bridge shown above.

- Range: 0.0001 to 10.1 ohms
- Limit of error: 0.25%
- Built-in battery and high sensitivity "Pointerlite" galvanometer
- Provision for external battery and galvanometer when required
- Sturdy and convenient in operation

Wheatstone and Kelvin bridges in a variety of models, together with other resistance measuring instruments, are fully described in Bulletin 100 available on request.

SPOTLIGHT GALVANOMETER

- Sturdy, short period
- Sensitive (up to 0.0006 μA per mm.)
- Multiple-reflection optical system
- For null or deflection measurements

Described in Bulletin 320

OTHER RUBICON INSTRUMENTS

Resistance Standards • Mueller Bridges • Precision Potentiometers • Evelyn Photoelectric Colorimeter for chemical analysis • Automatic Recording Photometric Analyzers for NO and H_2S • Magnetic Permeameters • Magnetic Hardness Testers • Shorted-Turn Coil Testers • Other equipment involving precise measurement of electrical quantities.

RUBICON COMPANY
Electrical Instrument Makers
3755 Ridge Ave. • Philadelphia 32, Pa.

nium rectifier stack or any wave circuit), require pulses of less than 0.1 watt for tripping, and are available with resistances from low values to 10000 ohms. For some types of "memory" applications a high-sensitivity adjustment is provided and power requirements are as low as a few milliwatts (relay tripped by a 50-volt charge on a ¼-mfd capacitor). Applications include momentary-contact controls, various protective circuits, etc.—*Sigma Instruments, 70 Ceylon St., Boston, Mass.*

Please mention number 635 when filling out card

Oscilloscope for Hydraulic-system Analysis

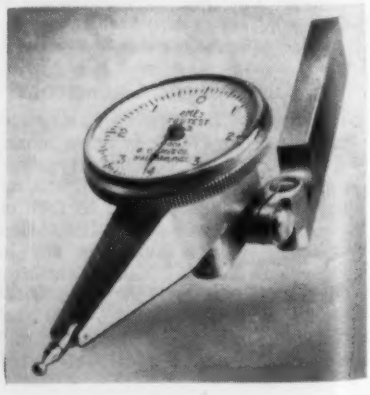
New "Hydrauliscope" was developed especially for checking pressure surges, etc., occurring in hydraulic systems. It

comprises a pressure pick-up (various ranges available), a specially-designed amplifier, a specially-designed cathode-ray oscilloscope with flat frequency response from 0 to 20,000 cps., etc. Apparatus is said to give consistent results when used by persons unfamiliar with electronic devices.—*Aeroquip Corp., Jackson, Mich.*

Please mention number 636 when filling out card

Dial Indicator

New "Trutest" universal dial indicator features automatic reversible action that eliminates the tripping of a latch in changing from "over" to "under" work. Another feature has indicator hand always moving clockwise, whether top or bottom of contact point is in use. Dial is 1 3/16" diameter. Two



contacts are furnished: 0.100″ dia. and 0.031″ dia. Also two support bars: ¼″ wide for tool post work, and ⅛″ wide for height gage work. New "Trutest" is available in two models, No. 1 reading in 0.0005″, with 0-15-0 dial; No. 2 reading in 0.0001″, with 0-4-0 dial. Contacts are all interchangeable in both models.—*B. C. Ames Co., Waltham 54, Mass.*

Please mention number 637 when filling out card

Reversible Plug Gages

New reversible plug gages are made of Norbide, said to be "almost unwearable" and to give new gages "200

times the service life of old style taper lock steel gages." Plugs reverse quickly in positive-locking, pin-vise handle. Aluminum handle minimizes weight. "Go" end is finished in green: "No-Go" in red.—*Size Control Co., 2500 Washington Blvd., Chicago 12, Ill.*

Please mention number 638 when filling out card

Stainless Steel Vacuum Flasks

New stainless-steel Dewar flasks feature new principles of construction; contain a new type of radiation shield (pat. appl. for). They are said to be unbreakable and explosion-proof; also if punctured or otherwise damaged, easily repairable. Any gases which might cling to the metal surfaces are absorbed by activated charcoal contained in a section of the evacuated space. Seams are interlocked for greater strength. Six sizes are available, ranging in capacity from 400 ml. to 50 liters. Intermediate capacities are obtainable by variations in depth. Largest size (13″ I.D. × 24″ inside depth) is furnished with an extra outer casing equipped with carrying handles. Special units can be made to order.—*Scientific Glass Apparatus Co., Bloomfield, N. J.*

Please mention number 639 when filling out card

Diaphragm Motor

New "Series 600 Diaphragm Air Motor" is designed primarily for use with maker's "Adjustable Port Valves" but can be used to operate various types of valves, dampers, rheostats, etc. It is designed for 0-15 lb./in.^{2} control-instrument air pressure and the 10-lb. range of 3 to 13 lbs./in.^{2} results in full travel of motor arm (26°) and develops 25

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FOR RATE OF FLOW AND LIQUID LEVEL MEASUREMENTS

Suitable for Static Pressures Up to 3,000 P.S.I.

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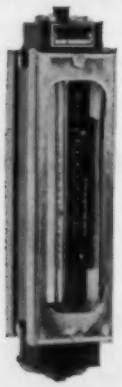
The Full-View
ROTAMETER



gives research flexibility!

The Full-View Rotameter provides extraordinary help to the research or pilot plant worker for flow rate measurement. Four pyrex metering tubes of different capacities will fit into one rotameter case. Also each tube has four floats that have individual ranges. Thus with one frame, four tubes and sixteen floats, a liquid range of 0.2 c.c. to 200 c.c. per minute and a gas range of 10 c.c. to 7000 c.c. per minute may be obtained.

With brass or steel end fittings, the price of all this equipment is only $101.00. With type 304 stainless steel fittings, the price is $130.00. Delivery from stock. A set-up like this one on hand will give you the equipment to measure *immediately* any flow rate requirement that may come up in your research. For full information, write Brooks Rotameter Company, Box A-2647, Lansdale, Pa.

BROOKS ROTAMETER CO.
LANSDALE, PA.

lb.-in. torque for 1 lb. change in controller pressure. (These ratings are for "No. 600-65" size.) Provisions have been made for a valve positioner to maximize valve-response accuracy. Mounting lugs are provided for fastening to supports independent of piping and motor can be mounted in any position relative to piping. Deliveries can be made from stock.—*The North American Mfg. Co., 4455 E. 71st St., Cleveland 5, Ohio.*

Please mention number 640 when filling out card

Electro-analysis Apparatus

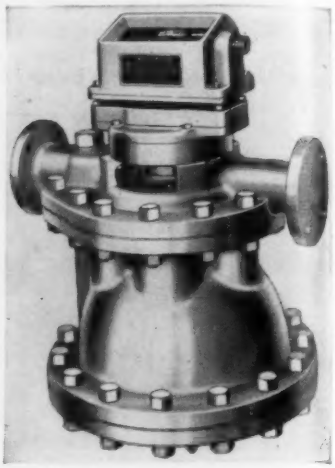
New model of Electro-analysis Apparatus is built for constant service, is adaptable also for research work. Built-

in selenium full-wave rectifier delivers 8 volts 5 amperes d.c. at both spindles for simultaneous determinations or 10 amperes d.c. for a single determination. Stirrers rotate at constant speed of 550 r.p.m., are adjustable for height. All electrodes including rotating type may be used. When using rotating anode set-up, no circuit changes are required. Instruments and mechanism are enclosed to protect them from acid fumes. Several units may be "banked" side by side for bench or wall mounting. Auxiliary heaters are available. Apparatus may be used on either 110- or 220-volt 60-cycle single-phase a.c. Power requirement 400 watts maximum. Height overall 29½", table space 14½" wide by 16½" deep.—*Eberbach & Son Co., Ann Arbor, Mich.*

Please mention number 641 when filling out card

Liquid Meter

New 1½" 50-g.p.m. positive-displacement meter is for applications requiring stainless steel equipment to prevent



corrosion, discoloration or contamination. In design and principle of operation it is basically similar to maker's "Industrial Xacto" meter but is constructed of stainless steel. Maximum working pressure 250 lbs./in.^{2}.—*Bowser, Inc., Fort Wayne 2, Indiana.*

Please mention number 642 when filling out card

Automatic Gage and Sorter for Rolls, etc.

New automatic hopper-fed roll selector for 100% inspection of length and diameter of small precision parts such

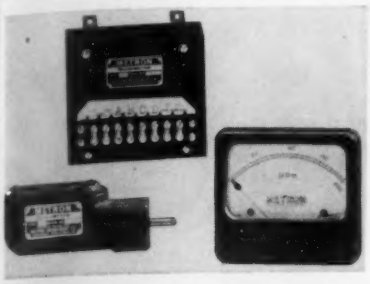
as roller bearings, dowel pins, chain links, etc., gages to a tolerance of 0.0005", segregates rolls into four classifications at rate of 3600 per hour. Range of adjustment, $\frac{7}{32}$" to $\frac{31}{32}$" on diameters and $\frac{9}{32}$" to 3" on lengths. After setting up (using minimum and maximum masters or two parts known

to be correct size) the rolls are placed in a hopper. All parts that contact the rolls are made of materials that prevent magnetic congestion of rolls.—*The Sheffield Corp., Dayton 1, Ohio.*

Please mention number 643 when filling out card

Electric Tachometers

New "Type 42" electric tachometer indicators are especially designed to be built into equipment, can be used with

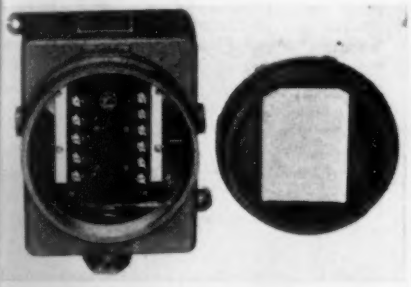


any of "Metron Tachometer Heads" for speeds from 1 to 100,000 rpm. More than 50 standard speed ranges are available and dial can be calibrated in any units such as knots, fpm., rpm., impressions per hour, etc. Operating power is obtained from 110-volt 60-cycle a.c. or whatever d-c. voltage is available. Accuracy is 1%.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Please mention number 644 when filling out card

Liquid-level Controller

New "Type 10CB1X Level Control" has been designed with particular consideration to problems of chemical proc-

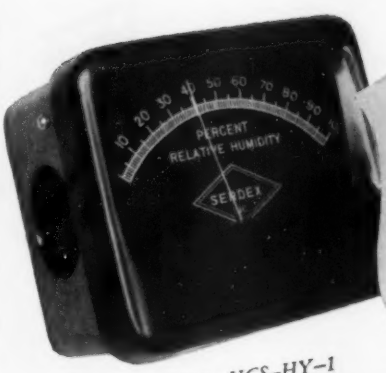


essing field. No vacuum tubes are used. Accuracy is independent of temperature and pressure. An a-c. probe circuit and transformer are combined to operate a d-c. relay. Two stainless-steel probe rods project into tank at levels corresponding to low point where pumping is to start, and high point at which pumping stops. "Type 10CB1X" is supplied as illustrated in an explosion-proof housing, or in a pressed-steel dust-tight enclosure; operates on 115/230-volts, 25/60-cycles a.c. A selection of four terminals on the terminal panel enables probe circuit to be matched to electrical conductivity of the liquid to be controlled. — *Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Please mention number 645 when filling out card

Electrical Prospecting Apparatus

New "Self-potential Apparatus" is a complete outfit for conducting prospecting and scientific investigations by the spontaneous polarization method. Principle: certain ore bodies and formations



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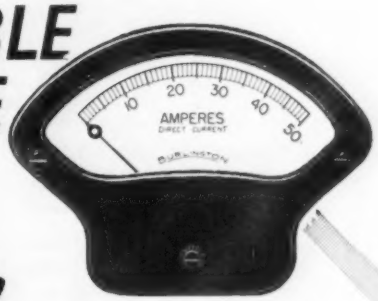

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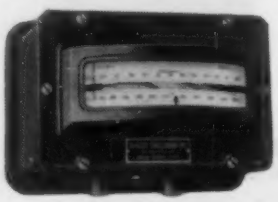
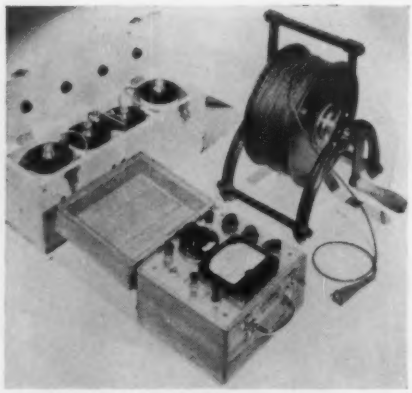


Model W-1
Switchboard Indicator

Unskilled help may handle this direct-deflection instrument, which needs no manual adjustment. Designed for numerous ranges of temperature, both F. and C.

Write for descriptive Bulletin 400

Charles Engelhard, Inc.
233 N.J.R.R. Ave. Newark 5, N. J.

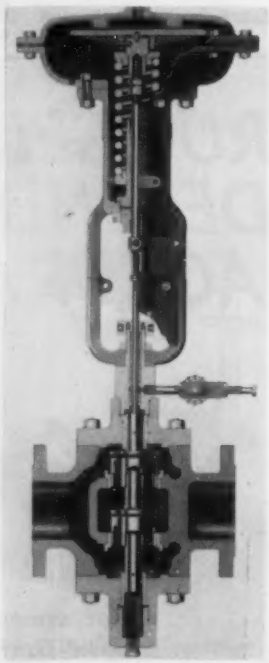


act as a sort of "battery." (Pyrites and graphite are two examples.) By making surface measurements at regularly-spaced stations, it is possible to determine location of such ore bodies. Apparatus consists of a light-weight sturdy field potentiometer, a set of four non-polarizing electrodes with a special carrying case, copper sulphate crystals required for non-polarizing electrodes, aluminum alloy reel with 1000 feet of high-strength light-weight field cable, etc.—*Geophysical Instrument Co., Arlington, Va.*

Please mention number 646 when filling out card

Diaphragm-motor Valves

New "Series 700" diaphragm-motor valves have anti-friction design and construction features, among them non-



buckling Neoprene diaphragm; ball pivot transmitting diaphragm force to stem; cradle mounting of upper spring flange preventing side thrust; "reinforced" parallel ground and squared spring ends; non-rising spring adjustment permitting use of widely different air-pressure ranges; duplex lubricated stem guide bearings, etc. Exclusive "Equipoise" valve body with diverted inlet balances velocity effect on disk and minimizes wear ("Direct Inlet" design optional for deposit-forming chemicals, etc.). Seven styles of inner valves make available all characteristics that may be required by automatic-control engineers.—*H. Belfield Co., Broad St. at Hamilton, Philadelphia 23, Penna.*

Please mention number 647 when filling out card

Variable-frequency Oscillator-wavemeter-detector

New "Model 59 Megacycle Meter" is a variable-frequency oscillator, an absorption wavemeter, an oscillating de-

tector and a tuned absorption circuit detector. Among uses: measuring capacitance, inductance, Q, resonant frequency, etc., generating signals, etc. Frequency range, 2.2 Mc. to 400 Mc.; modulation, CW or 120-cycle fixed at approx. 30% at 15 Mc., or external. Power unit is 5⅛" × 6⅛" × 7½", weighs 6½ lbs.; oscillator unit is 3¾" diam. × 4", weighs approx. 1 lb.—*Measurements Corp., Boonton, N. J.*

Please mention number 648 when filling out card

Vacuum Capacitors

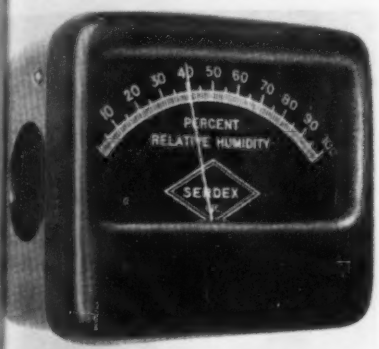
New series of vacuum capacitors is announced. Designations connote electrical characteristics. Thus in "CAP 50/-60/-30" (illustrated) first numeral designates capacitance in mmfd tolerance ±2%; second numeral safe current capacity in amperes; last figure peak potential in kilovolts. Capacitor is of low-loss construction, suitable for

high-frequency applications. Features are use of large elements; large-periphery glass-to-copper seals resulting in low temperature coefficient; end caps gold-plated to maintain low contact resistance. Over-all dimensions 2½" × 6½". — *United Electronics Co., 42 Spring St., Newark 2, N. J.*

Please mention number 649 when filling out card

Indicating Hygrometer

New "Model HGS-HY-1" laboratory hygrometer utilizes newly-developed "Serdex Humidity Sensitive Element"



said to be capable of a high degree of repeatability and extremely low lag (3.25 seconds). Instrument accuracy, ± 2% RH at ambient temperatures as high as 135°F. Weight, 11 oz. Size, 4" × 4½" × 3".—*Serdex, Inc., 91 Cambridge St., Boston 14, Mass.*

Please mention number 650 when filling out card

Surveying Odometer

New one-man odometer is of dustproof construction, weighs 8½ lbs., has a 9999-ft. quick-reset cyclometer reg-

ister. Clutch is of positive type: pull trigger to engage, press button to release.—*Matthews Instrument Co., 1129 Boylston St., Newton Upper Falls 64, Mass.*

Please mention number 651 when filling out card

Transparent-case Electrical Instruments

New 3¾" panel instruments have unbreakable-front "Crystal Clear Plastic" case which gives more usable scale

You're FACE TO FACE WITH ALL THE FACTS

At a glance, the face of this CORBIN Tachometer will tell you the number of TONS PER HOUR, TONS IN BATCH and TOTAL TONS up to that time. Whether you're counting tons or cases, bottles, bales . . . or measuring in lengths, or counting revolutions . . . Corbin can engineer a Corbin Tachometer to meet your requirements.

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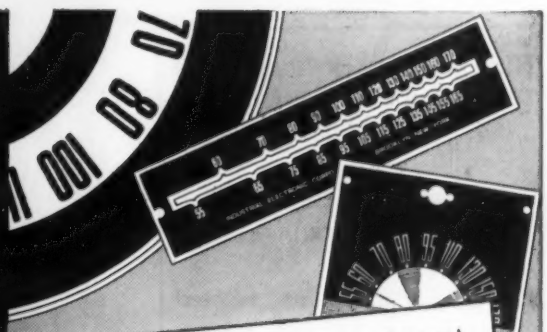

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Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest stream; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

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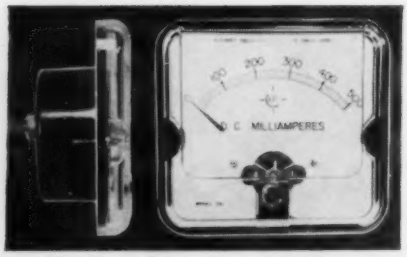
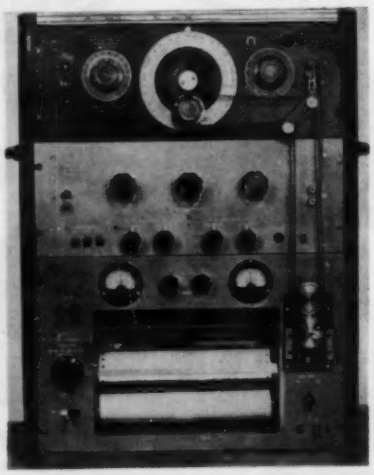


space and permits more light to reach dial for easier reading. Dial can be finished in colors to harmonize with equipment on which new instruments are used. Instrument is readily illuminated from front or rear: light on back of case will "pipe" through plastic to cast soft illumination on dial. Shock-resistant movement has polished pivot bearings and vee jewels. Available types: moving-coil, repulsion-iron-vane, rectifier, thermocouple high-frequency, and pyrometer; all popular ranges of volts, millivolts, milliamperes and amperes, both a.c. and d.c. For ultra-sensitive microammeters, specially-designed Alnico 11 magnets are used. Instrument measures 3¾" wide by 3⅜" high and projects less than ⅝" in front of panel.—*Assembly Products, Inc., Chagrin Falls, Ohio.*

Please mention number 652 when filling out card

Impedance Analyzer

New "Impedance Vectograph" makes possible direct graphical recording of resistive and reactive components of an

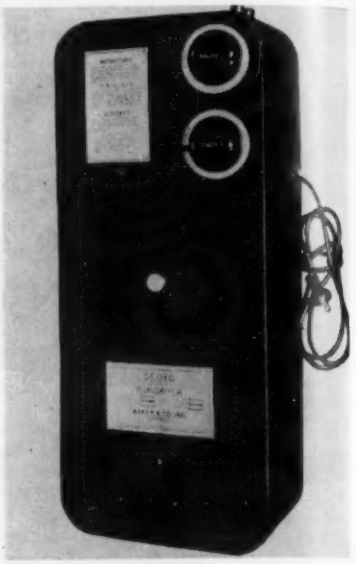


impedance as a function of frequency, when used in conjunction with maker's "Twin Recorder" and a beat-frequency oscillator. Resistance and reactance can be separately, and simultaneously, measured and recorded from 1 to 4000 ohms in 6 ranges with separate expansion of either scale of ½, ⅛, or 1/10 of the other scale. A reactance polarity check is provided to show on record whether reactance is positive or negative. New instrument is useful for measurements on transducers, filters and transmission lines.—*Sound Apparatus Co., 233 Broadway, New York 7, N. Y.*

Please mention number 653 when filling out card

Gas Dryer-purifier

New "Deoxo Puridryer" is an automatic instrument which removes oxygen impurities and eliminates moisture from gases. Installed on low-pressure line, it purifies hydrogen, for example, so that less than 1 ppm. of oxygen impurities remains, and then dries the gas to dew points of better than —50°F. It may also be used with such gases as nitrogen, argon, neon and saturated hydrocarbons. Capacity depends upon moisture content and impurity of incoming gas. Using bottle hydrogen of 99.7% purity and a maximum flow of 50 cfh., pure gas with dew points better than —50°F. for over 36 hours of

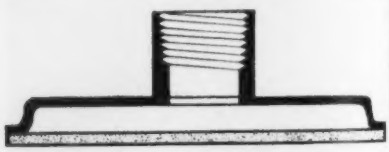


continuous operation is attained. This is equivalent of almost nine bottles of hydrogen. It is said that purifying catalyst should last indefinitely unless poisoned by sulphur compounds, CO or some organic solvent vapors (rarely found in commercial hydrogen).—*Baker & Co., Inc., Newark 5, N. J.*

Please mention number 654 when filling out card

Porous Stainless Steel Spargers

New industrial gas dispersion units, in standard sizes, consist of a disk of porous stainless steel welded about its

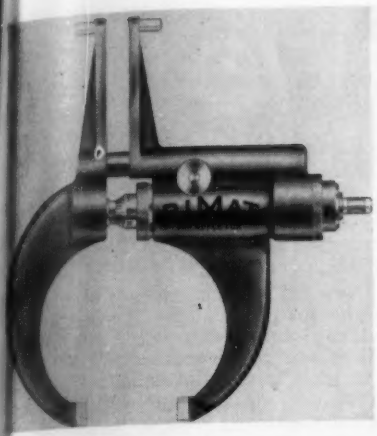


periphery to a shallow stainless steel dish welded to a standard female pipe connection. In use, required number of pipe connections are provided at bottom of tank, and spargers are then screwed into place. Porosities range from 5 to 65 microns. Flow capacities for all grades are said to be high, with unusually low pressure drops. Diameters available in porous elements are 1", 1½", 2⅜", and 3½"; pipe connection sizes are ⅛", ¼", ⅜" and ½". Special sizes and shapes can be supplied.—*Micro Metallic Corp., 193 Bradford St., Brooklyn 7, N. Y.*

Please mention number 655 when filling out card

Inside and Outside Micrometer

New "Rimat" duplex micrometer for internal and external measurements is announced in three sizes: 0-1", 1"-2",

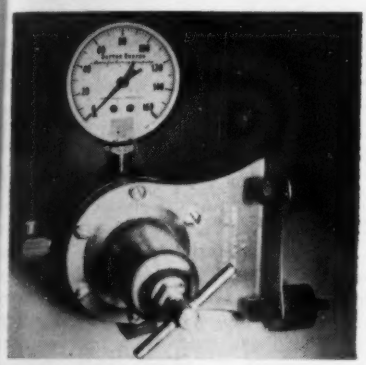


and 2"-3". Special sizes to order. Ends of measuring pins are hardened and ground on a radius for accuracy and to prevent cramping. All wearing surfaces are hardened and ground. All wearing surfaces can be readily adjusted.—*Richards Machine Tool Co., 124 South Isabel St., Glendale 5, Calif.*

Please mention number 656 when filling out card

Combination Reducing Valve and Gage

New combination reducing regulating valve and pressure gage is made in ¼", ⅜", ½" and ¾" pipe-size connections. Valve reduces line pressures to a desired lower working pressure (5 to 150 lbs./in.²), automatically maintaining such pressure. Gage indicates regulated pressure. Each unit is provided with two rubber shock-absorbing vibration dampers. — *Dayton Rogers Mfg. Co., 2835 12th Ave. South, Minneapolis 7, Minn.*



Please mention number 657 when filling out card

Laboratory Mixer

New counter-rotating mixer is said to make available in the laboratory, mixing speeds and results hitherto obtainable only in large production equipment. Use of two motors, driving two propeller-equipped concentric counter-rotating shafts, produces annular rather than circular flow. All materials including heavier particles are rapidly drawn into the propellers where they pass through a shearing zone. It is said that there is practically no cavitation, no centrifugal effect, and liquid level remains essentially constant, allowing use of nearly-filled containers. Two 1/30-hp. motors allow relative speeds from approx. 200 to 12,000 rpm. and continuously-variable speed control is pro-

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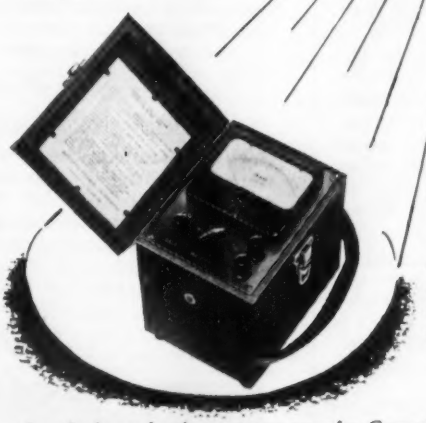

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Measures directly, accurately, instantly from 1 ohm to 100,000 ohms.

Ample long lasting power supply. Completely self-contained, using two No. 6 dry cells. • Individually calibrated wire wound resistors for extreme accuracy coupled with unusually long hand stepped meter scale. • Ruggedly built in sturdy metal, wrinkle finished case, which provides shielding from external magetic fields.

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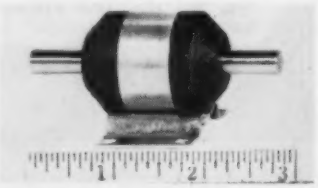
vided by a General Radio "Variac." For d-c. use, a rheostat can be supplied in place of the "Variac." New mixer comes complete as shown.—*Brookfield Engineering Labs., Inc., Stoughton, Mass.*

Please mention number 658 when filling out card

Miniature Speed Changers

New speed changers for instruments, etc., have over-all length of $2\frac{1}{16}$" and body diameter of $1\frac{1}{16}$", are available



in gear ratios of 15, 10, 9, 8, 7, 6, 5, 4, 3, 2, $\frac{3}{2}$, $\frac{4}{3}$, $\frac{5}{4}$, $\frac{6}{5}$, or $\frac{10}{9}$. Speeds up to 20,000 rpm. and torques up to 2 lb.-in. are permissible for some applications. Drive shafts are mounted in permanently-lubricated ball bearings, intermediate gears in graphitic plastic bearings.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

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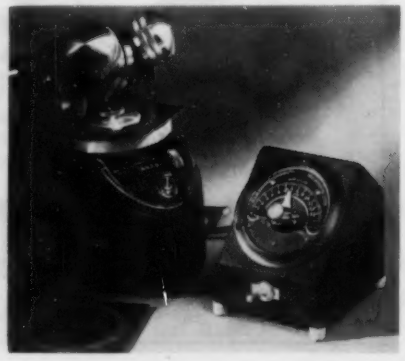
Accessories for Abrasion Tester

Three new accessories developed for use with "Taber Abraser" are announced: (1) Interval Timer (illustrated) enables research laboratory personnel to time abrasion tests within prescribed limits; (2) Duplex Refacing Stone for "Calibrase" abrading wheels assures more dependable standardization of wheels than previously possible,



also gives greater economy in use; (3) "Abraser Drymount," a dual-coated adhesive sheet, "anchors" thin flexible specimens to metal or cardboard backing to prevent wrinkling or buckling during test.—*Taber Instrument Corp., 111-I Goundry St., North Tonawanda, N. Y.*

Please mention number 660 when filling out card

"Y"-type Strainer

New "Y" type strainer is available in pipe sizes from ⅛" to 2", in either cadmium-plated rust-resisting cast iron or all-bronze construction. New strainers are built to 250-lb. standards for cast iron, are suitable for 400-lb. service when furnished with bronze body. Immediate shipment.—*A. W. Cash Valve Mfg. Co., Decatur 60, Illinois.*

Please mention number 661 when filling out card

CONSISTENCY CONTROL

(Continued from page 540)

and the only question (whether "consistency head" coincides with "consistency" as discussed above) does not bear on the performance of whatever mechanism is selected to obey the commands of the primary element.

The next distinction made by Behar is: "(1) *Continuous;* (2) *Discontinuous,*" and he has often pointed out the advantages of continuous indications in automatic-control engineering. From Fig. 2 it is plain to see that the indication is continuous, eliminating the headaches of trying to speed-up an intermittent-sampling method of consistency measurement.

In discussing the "quality" of the indication fed to an automatic controller, Behar explains that the *precision* must be related to the control application (pyrometry, etc.). It is plain to see from Figs. 3 and 5 that a change of one-tenth of one percent in consistency produces a change of ¾" in consistency head—more than ample for obtaining close control with simple, rugged mechanisms.

So then, if it is true, as Behar put it, that "no controller can be better than its primary measuring element," the new method gets over the first big hurdle. But the problem of automatic consistency control is made difficult by two things: First, the process lags involved; second, the relatively large power required to carry out the commands of the measuring system.

Experience to date seems to indicate that in any screen-room or wet-machine operation, process lags from 25 seconds initial reaction to 90 seconds complete reaction time are encountered. Inasmuch as in high-production mills at these low consistencies, flows up to 8000 gpm. are frequently encountered, it is obvious that automatic-control equipment of a high order of stabilization, speed and power is necessary if the requirements of successful control are to be fulfilled. Such equipment is available but this article is not the place for describing commercial products already known to most *Instruments* readers.

JOURNAL of the Instrument Society of America

Editor, R. R. PROCTOR, 2213 Ridge Ave., Evanston, Ill.

Vol. 2 JUNE 1947 No. 6

Editorial

Are Your Meetings Conducted Properly?

The Sections Committee of the I.S.A. has, we regret to say, been publicized very little in the columns of the *Journal*. Its work, however, has been carried on quietly and efficiently since the committee's inception several months ago, and at least eight new Sections have been formed or chartered as a result of the committee's efforts. The chairman of the Sections Committee is J. B. McMahon of Chicago, one of the four Vice-Presidents of the Society. Another Vice-President, H. H. Barnum of Detroit, and C. F. Goldcamp, Pittsburgh (Chairman of the Employment Committee), are the other members of the committee.

We recently had the pleasure of reading a report submitted by the Sections Committee to the Board of Directors, and it is, in our opinion, one of the most constructive reports we have ever seen. Among the many suggestions offered in this report are several regarding the conduct of meetings. We believe these suggestions should be brought to the attention of every national and sectional officer, committee chairman, technical chairman or other individual who at any time has or will have a part in the handling of any meeting. Therefore, at the risk of being accused of plagiarism, we would like to quote and expand a bit on the suggestions of the Sections Committee pertaining to the conduct of meetings.

Incidentally, the committee, and particularly "Mac" McMahon, has been getting around considerably, and the suggestions listed in the committee report are based on the observation of the operations of *more than half of the present Sections*. We feel that Mac knows whereof he speaks when he says that "In many cases . . . advice (on the conduct of meetings) is not necessary, but it is necessary often enough to make it worth while to mention (in this report)."

The first suggestion proposed by the committee, and probably the one which hits most of us in our weakest spot, is that meetings of all kinds conducted for the purpose of furthering the aims of the Society should be surrounded with some dignity and formality. This serves several purposes, not the least of which is its effect on guests and visitors. It lends an air of importance which is very helpful in persuading potential members of the value of the Society's existence. It increases the influence and the prestige of the officers or chairmen responsible for the meeting, and it makes for a more smoothly flowing meeting which is a source of satisfaction to all present.

Chairmen conducting business meetings should become acquainted with Robert's *Rules of Order;* each Section should own a copy and insist that it be used. If a copy is not available for the officers of your Section, it is our suggestion that your local Secretary be authorized to buy a copy and then, acting as librarian, check it out to the various officers and chairmen who will be responsible for the meetings to come. With so many Sections electing new officers for the 1947-48 season starting in September, now is the ideal time to see that this book is made available to the new officers, some of whom may never have conducted a meeting before.

Another of the Section Committee's suggestions is that each Section have an active Properties Committee—or make one person on the Program, Housing, or Arrangements Committee responsible for seeing to it that properties are available and on hand when needed. Such properties include projectors, screens, pointers, blackboard, chalk, eraser, water pitcher and glass, etc. It is rather disconcerting to a speaker to find at the last minute that someone forgot the extension cord for the projector and that, as a result, he cannot use his slides, or that there is no chalk on the blackboard just as he is about to illustrate an important point.

In this same connection, it is certainly not fair—in fact, it is a serious offense—to ask the speaker to provide his own paraphernalia such as projectors, screens, etc. His needs should be ascertained far enough in advance by the chairman of the meeting so that *everything necessary* will be on hand when the meeting opens. Further, if slides are used, someone familiar with the operation of the projector should be assigned to the job of running it. It is true that even the best operators sometimes get a slide in upside down, but this is not the way to bring a laugh into the scene. Let the speaker do that if he is so inclined. Careful handling of the slides will minimize this sort of interruption, and if your operator can't recognize an out-of-focus condition on the screen—and correct it—it's time to get another operator!

Speakers should be treated with consideration. This implies that, among other things, meetings should be started on time. It is not fair to anyone present, and most of all the speaker, to postpone starting the meeting for perhaps a half-hour or an hour waiting for the audience to straggle in. (This works both ways; it is likewise thoughtless of the speaker to arrive late or to arrive unprepared and require time to get his papers, slides or equipment ready. However, as members of the audience, we should make every effort to be there on time so the speaker will not be disturbed by too many late-comers, and if we are responsible for the conduct of the meeting, we should make every effort to have everyone present on time and start the meeting as per schedule.)

Due to space limitations, there are many other things which will have to remain unsaid in this editorial, including other minor suggestions by the Sections Committee, but it is hoped that the few suggestions we have made or quoted herein will be sufficient to encourage all those responsible for the handling of Society meetings of any sort to conduct them as they should be conducted. As the Society grows in size, it must and will also grow in its importance among other engineering and technical societies, and its prestige and influence, as well as its value to its members, depends in no small way upon the efficiency and propriety with which its meetings are conducted. We can all do our share toward furthering this effort. —RRP

Editor's Notes

1. Who's Who

The "officer of the month" this time in our "Who's Who" column is Dr. Ralph H. Munch, Vice-President, of St. Louis, who was until recently also Chairman of the St. Louis Section. Appropriately enough, our Delegate this month is William E. Boyle, also from St. Louis, and it is a coincidence that "Bill' is also a member of the committee whose chairman occupies the third "seat" in this month's "Who's Who" department. Our committee chairman this time is F. H. Trapnell, or "Trap" as he is called, who heads the Recommended Practices Committee. It is not a coincidence that some of the activities of Trap's committee are also written up in this issue of the *Journal*, since it is this kind of "pairing-up" that we strive for each month.

2. Exhibit Information Released

Elsewhere in this issue will be found the latest information released by the National Office on the status of the 1947 Exhibit to be held in Chicago this coming September 8th to 12th inclusive. The floor plan of the Stevens Hotel Exhibition Hall is shown with all spaces reserved to date indicated in color. In conjunction with this diagram is the latest list of exhibitors who had contracted for space as of press time for this issue.

As can be seen on this diagram, there are but a few spaces as yet unsold, and there are applications pending for some of these, according to T. G. Robinson, chairman of the Exhibit Committee, and D. J. Bergman, chairman of the Space Allocations Committee. From all indications to date, the show will be a complete sell-out. This, in conjunction with the excellent technical Conference being arranged (some of the papers for which are listed also in this issue) promises one of the finest and most instructive conferences ever to be arranged in this country for men in

Continued on page 572

Surface Finish Measurement Instrumentation

By JAMES A. BROADSTON, North American Aviation, Inc., Los Angeles

(Concluded from April)

No attempt will be made to go into the details of operation of the various types of surface finish measuring devices because much has already been written and published that discusses these devices thoroughly. Those who are interested in the practical side of the problem are not concerned anyway as long as a satisfactory index to the surface quality can be obtained without damaging the parts.

Challenge To Technicians

For those who are technicians, electronic experts and instrument designers, and who are interested in accepting the challenge for the improvement of surface finish measurement instrumentation, a few remarks follow that will assist in becoming familiar with some of the problems involved.

In the first place there are so many different types of surfaces that it would be impossible even to count them. To the naked eye, we have the surfaces of a wire mesh screen, the plastered wall, the granite building, an alligator's skin, a fuzzy peach and many others, each completely different. When we take a small magnifier we find almost everything we own has a characteristic surface texture. Consider as examples pieces of paper, leather, canvas, cloth, wood, linoleum, wallboard. Each is different than the other. Even by the eye alone it is easy to distinguish between the machine finishes produced by milling, turning, lapping, honing, grinding, etc., as each process leaves a different characteristic surface roughness.

When it is realized that there are not only so many different types of surfaces, but also many degrees of roughness for each it is not surprising that no one has yet found a surface finish measuring instrument that can begin to do the whole job. One should not, therefore, be too critical of existing instrumentation. Many smart men and many technical groups have studied the problem without startling results. It still holds a challenge for the instrumentation industry to do better. Even existing instruments of a type often do not give the same reading on a given specimen. Even our practical man doesn't want that.

Instrumentation Advances Art

Surface finish measurement instrumentation should be considered to include not only commercially available instruments such as tracer point analyzers, optical comparators, reflectivity or gloss meters and sample roughness blocks, either originals or replicas, but also all other devices for the purpose that have been used experimentally.

Tracer point analyzers have contributed more to the advancement of surface quality control than any other single factor. With all their precision as instruments, however, a recent unbiased study conducted by the National Bureau of Standards and the Army Ordnance Department showed that their readings are not always consistent or dependable over a wide range of surfaces. The fact that the tracer point itself induces certain errors due to its inability to precisely follow all of the surface irregularities, plus inherent differences in the response characteristics of the pickups, amplifiers and meters involved makes duplication of results quite difficult. There is still much room for improvement.

It is this inability to duplicate readings that is delaying national standardization of surface roughness symbolism for machined parts. No one has yet designed a surface roughness measuring instrument that can be produced in quantity and yet maintain its accuracy or calibration so that all instruments will give the same reading on any given surface. The problem is not an easy one.

Performance Criteria Needed

Another consideration is that no generally acceptable criteria have ever been evolved that will truly correlate the performance of different machine finishes. This is largely due to the fact that so many factors are involved. Different materials, various types of finishes and thousands of applications make the problem of correlating performance more difficult.

Further, no agency has ever taken over a project to make a thorough and careful study of the results and observations of the many investigators. No attempt has ever been made to correlate them, to make tests to confirm discount their findings, or to determi if there might be a sound fundamen basis on which such performance c be measured and predicted. Such a p gram might well fit into the resear facilities of a large university if indu try is willing to help finance the proj and take enough interest in it to ass and guide its work so that the resu will be worthwhile.

As a result, it is doubtful if the called RMS (root-mean-square) ave age deviation from the mean in micr inches (which is the generally acce

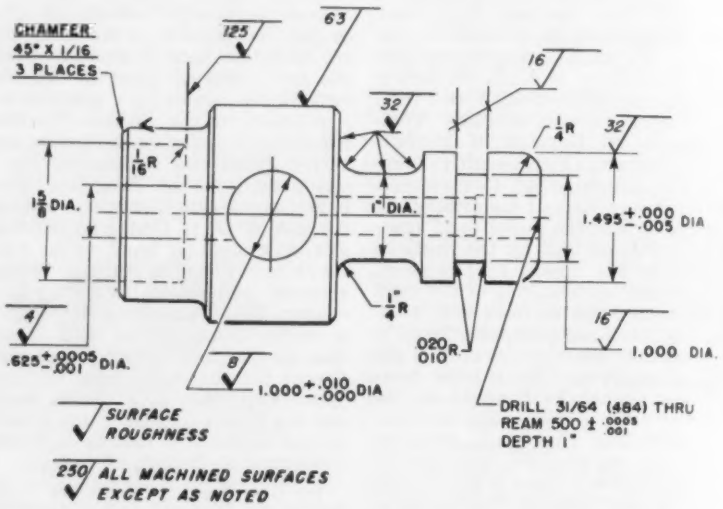


Fig. 6. Typical applications of surface roughness symbols (flags optional).

able unit for machine finish designa tion) is really any good, or for tha matter any better than the ordinar arithmetical average as an index to th roughness of any machined surface. A the present time, the trend is towar forgetting the RMS complication an using the arithmetical average unti a really suitable index to performanc has been evolved from tests on repre sentative surfaces whose roughnesse are adequately known. Until researc establishes the best index, surface fin ish measuring instruments will have t base their readings on existing units.

A recent survey conducted among th leading aircraft manufacturers by th National Aircraft Standards Commit tee revealed a preference for using th arithmetical average of by a vote of 2 to 2. This preference was solicited i the interest of simplification, since i appears that the difference between th two units is less than the acceptable tolerances and within the accuracy range of existing instrumentation.

Progress Requires that Fundamentals Be Established

H. Wright Baker, D.Sc., M.I., Mech E., M.I. Aut. E., Professor of Mechani

cal Engineering for, I believe, the University of London, in introducing a "Report on the Measurement of Surface Finish by Stylus Methods" published in 1944 by the Research Department of Taylor, Taylor & Hobson, Ltd., of Leicester, England says:

"In the development of new technical processes it is of primary importance that the fundamental principles upon which they depend should be established as early as possible if misunderstandings and mistakes are to be avoided and steady progress is to be made.

"Taylor, Taylor & Hobson, Ltd., have rendered a notable service to engineers by preparing and publishing a concise and thorough report on the principles underlying the action of stylus instruments, the interpretation of surface records, and the limitations to be considered.

"This account of their own pioneering work, giving indications of further data which needs to be acquired, should provide a stimulus to other workers and contribute much towards establishing our knowledge of Surface Finish on a broad scientific basis."

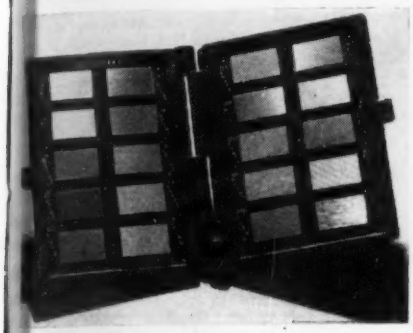


Fig. 7. Stainless steel specimens. (Courtesy University Machine Co.)

No further recommendation of this excellent work is necessary. The serious researcher into these problems would do well to read it and profit thereby.

Practical Application Now Possible

The practical man should not allow these facts to worry him unduly for with any given instrument he can control the processing of his product within extremely close limits. By making samples of the surfaces that have given satisfactory performance, he can, by direct instrument comparison, keep all further production under control. This is particularly true for very fine surfaces that are very essential to the continued satisfactory performance and life of his product. The Profilometer, manufactured by Physicists Research Company of Ann Arbor, Michigan, and the Brush Surface Analyzer manufactured by the Brush Development Company, Cleveland, Ohio, are tracer point surface finish measuring instruments suitable for such work. The Comtor Surface Finish Comparator manufactured by the Comtor Company of Waltham, Massachusetts, is one of the reflectivity types of comparators. It is equipped with a light source and a photoelectric cell which measures the light reflected from the surface to be compared with the sample. The meter reading serves as an index to the surface roughness. It is also quite suitable for very finely finished parts.

Samples Distributed for Control

While nothing will take the place of these precision instruments in measuring, or shall we say comparing, the surface roughness of very fine machine finishes, there are many rougher surfaces that also need adequate control in the shop. Many manufacturers have found that the procurement of sets of standard surface finish samples for distribution to their workers has solved the problem as far as the average machine finishes are concerned. This can usually be done for an expenditure of considerably less than one hundred dollars if the plant is not too large, whereas even one tracer point analyzer costs over a thousand dollars. In many cases, even such an expense is justified; some manufacturers have dozens of tracer point analyzers in one department. In other cases, it may not be justified and for those the use of standard roughness samples accomplishes the required control.

Control Requires Drawing Designation

Both methods, however, require the use of a proper system of drawing designation. One method now in use by industrialists all over the world is described in my text titled "Control of Surface Quality," available from the Surface Checking Gage Company, Hollywood 28, California. Such a method of drawing designation and quality control (See Fig. 6) can be accomplished by using as a reference a set of standard roughness samples. There are several types available and any of these which appeal to the user can be used in such a program. Those of the University Machine Company, Cambridge, Massachusetts are among the best stainless steel machined specimens obtainable for purposes of comparison (Fig. 7). The Norton Company of Worcester, Massachusetts, makes an excellent set of surface roughness standards depicting various grinding finishes that are also the original machined samples (Fig. 8).

Manufacturers of Replica Standards

In the field of replica standards there are several manufacturers: General Electric Company, Schenectady 5, New York (Fig. 9); U. S. Rubber Company, Electroforming Dept., Detroit, Michigan (Figs. 10 and 11); Surface Checking Gage Company, Hollywood 28, California (Fig. 12); NH Gage Company, North Hollywood, California (Fig. 13).

These replica standards have many advantages, too. Their lower cost permits a wider distribution, hence it is easier for all personnel along the line to check conformance with surface finish requirements. The engineer, inspector, machinist, assembler and everyone connected with the control of surface quality can easily, by fingernail comparison of the parts with the samples, tell if the parts are satisfactory insofar as surface finish is concerned.

Fingernail Comparison Detects Roughness

Comparison is made by drawing the sharp fingernail lightly across the surface of the standard roughness specimen prepared by a similar process and then across the machined surface of the part whose roughness limits are being checked. It is easy to tell which of the two surfaces is the rougher. By comparison with another of the standard roughness blocks, the finish of the part can be closely estimated.

Many times it has been shown that even an inexperienced person can immediately detect a difference of only a few microinches on some types of surfaces. It might be said that, when used in conjunction with a standard set of surface roughness blocks, each finger is equally sensitive to an instrument

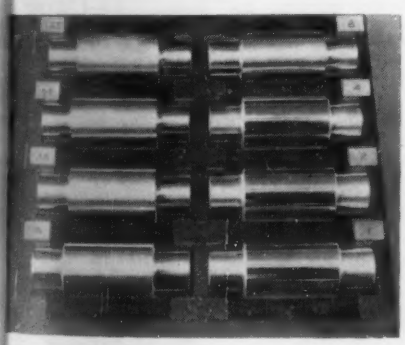


Fig. 8. Sample roll specimens. (Courtesy Norton Co.)

Fig. 9. Standard roughness specimens. (Courtesy General Electric Co.)

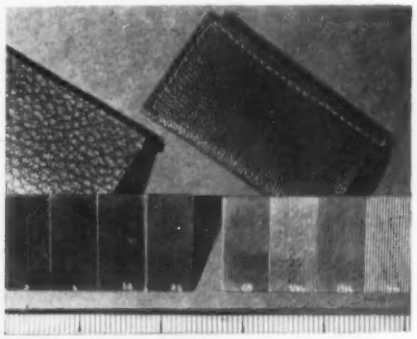


Fig. 10. Surface roughness comparators, pocket size. (Courtesy U. S. Rubber Co.)

Fig. 11. Surface roughness comparators, large size. (Courtesy U. S. Rubber Co.)

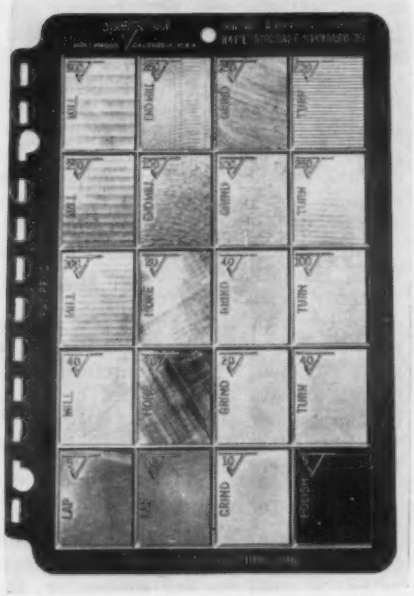


Fig. 12. Surface roughness standards. (Courtesy Surface Checking Gage Co.)

Fig. 13. Surface roughness specimens in use by engineer. (Courtesy NH Gage Co.)

worth over one thousand dollars. Each worker having ten fingers carries about ten thousand dollars worth of surface finish measurement instrumentation with him. All the practical man must do to use this abundant supply of instrumentation is to train his workers properly, adopt an acceptable method of drawing designation and supply the roughness standards for reference. For the rougher surfaces that are not critical from a performance standpoint, visual comparison with the standard surfaces has proved sufficiently accurate.

There are many other methods for evaluating surface finish that have not been successful enough to leave the laboratory. Others have helped immeasurably in certain applications.

Among these may be mentioned taper sectioning; the use of a phonograph pickup for comparison; optical sectioning by a straight edge shadow; film replicas for projection; taper sectioning by inclined light beam; air leakage or light leakage between the surface and a standard orifice; friction tests; oil adhesion tests; and honing stick tests. There is not time for a discussion of each of these, but reference to existing literature on the subject will reveal greater details about them.

Surface finish measurement instrumentation has already contributed a great deal toward the improvement of the science of interchangeable manufacture. With proper application, it can easily contribute a great deal more. With such great opportunities ahead for improved instrumentation, as well as improved utilization, the day may not be far off when the use of surface finish control will be as universal as dimension control is today.

Editor's Notes

(Continued from page 569)

all phases of the instrument field. *Now is the time to make plans to attend this Conference and Exhibit.*

3. THE NEEDLE POINTS TO—

Aruba—for the report of a most unusual "sales" type of meeting, but an excellent idea at that.

New York and Oak Ridge—for exceptionally well written and interesting reports. New York's required no editing whatsoever!

Little Needles (honorable mention) to Chicago, Detroit, Philadelphia and St. Louis for generally good reports.

—R. R. PROCTOR

Official News

TO ALL SECTION SECRETARIES

Here are some additional changes to be made in the previously published list of Section Delegates, Secretaries and *Journal* Correspondents:

1. New Secretary. St. Louis Section, William G. Lee, National Lead Co., St. Louis, Mo. (Delegate, W. E. Boyle; Correspondent, H. E. Zeffren; as before.)

2. New Correspondent. Northern Indiana Section, Edward L. White, 8833 Carolina Ave., Highland, Ind.

PAPERS NOW SCHEDULED FOR 1947 CONFERENCE

According to a recent announcement by the Papers Committee, most of the speakers and papers scheduled for the Second National Instrument Conference and Exhibit to be held in Chicago, September 8-12, 1947, have been arranged for. Following is a list of those already scheduled:

"Instrumentation Practices in the Oil Industry" by G. L. Larson (Texas Co.)

"Instrumentation Practices in the Steel Industry" by H. Morrow (Carnegie-Illinois Steel Company)

"Instrumentation Practices in the Chemical Industry" (speaker announced later).

"Instrumentation Practices in the Power Industry" (speaker announced later).

"Dew Point Recorder" by B. Suomi (University of Chicago).

"Quantometer" by J. R. Churchill (Res. Lab., Aluminum Co. of America).

"Quality Control—A Management Tool for Process Industries," by W. E. Jones (Management Consultant).

"Precision of Measurements" by F. Trowbridge (Sentinel Radio Company).

"Instrumentation of an Acetic Acid Concentration Process" by J. E. Voytilla (E. I. duPont de Nemours & Co.)

"Instrumentation of Process of Extracting Bromine from Sea Water for Production of Ethylene-Dibromide" by P. Hart (Dow Chemical Co.).

"Measurement & Control of Viscosity" by D. J. Pompeo (Shell Development Co.).

"Polarographic Analysis — Principles, Techniques, and Applications" by L. D. Wilson (Corn Products Company).

"Adaption of the General Electric Spectrophotometer for Special Measurements" by E. I. Stearns (Calco Chemical Co.).

"Instrumentation of an Alkylation Plant" by H. Moore (Std. Oil Co. of N. J.).

"Water Conditioning and Steam Plant Control with Conventional Industrial Instruments" by W. H. Fortney (Humble Oil Company).

RECOMMENDED PRACTICES COMMITTEE NOW AT WORK ON SEVERAL PROJECTS

One of the most important committees of the Society, the Recommended Practices Committee has almost completed two of its projects, has several others under way at present, and is shortly to undertake several more, according to recent information from F. H. Trapnell, chairman. A recent letter from Mr. Trapnell lists the names of the members of the committee:

F. H. Trapnell, Chairman, 711 Bellevue Road, Wilmington 280, Del. (Phila. Sec.)

A. F. Sperry, Acting Secretary, 225 W. Michigan Ave., Chicago 1, Ill. (Chi. Sec.)

W. E. Boyle, St. Louis Section.

W. G. Brombacher, Washington Section.

A. L. Chaplin, New Jersey Section.

W. A. Crawford, Philadelphia Section.

W. H. Fortney, Baytown, Texas (non-member).

R. L. Galley, Philadelphia Section.

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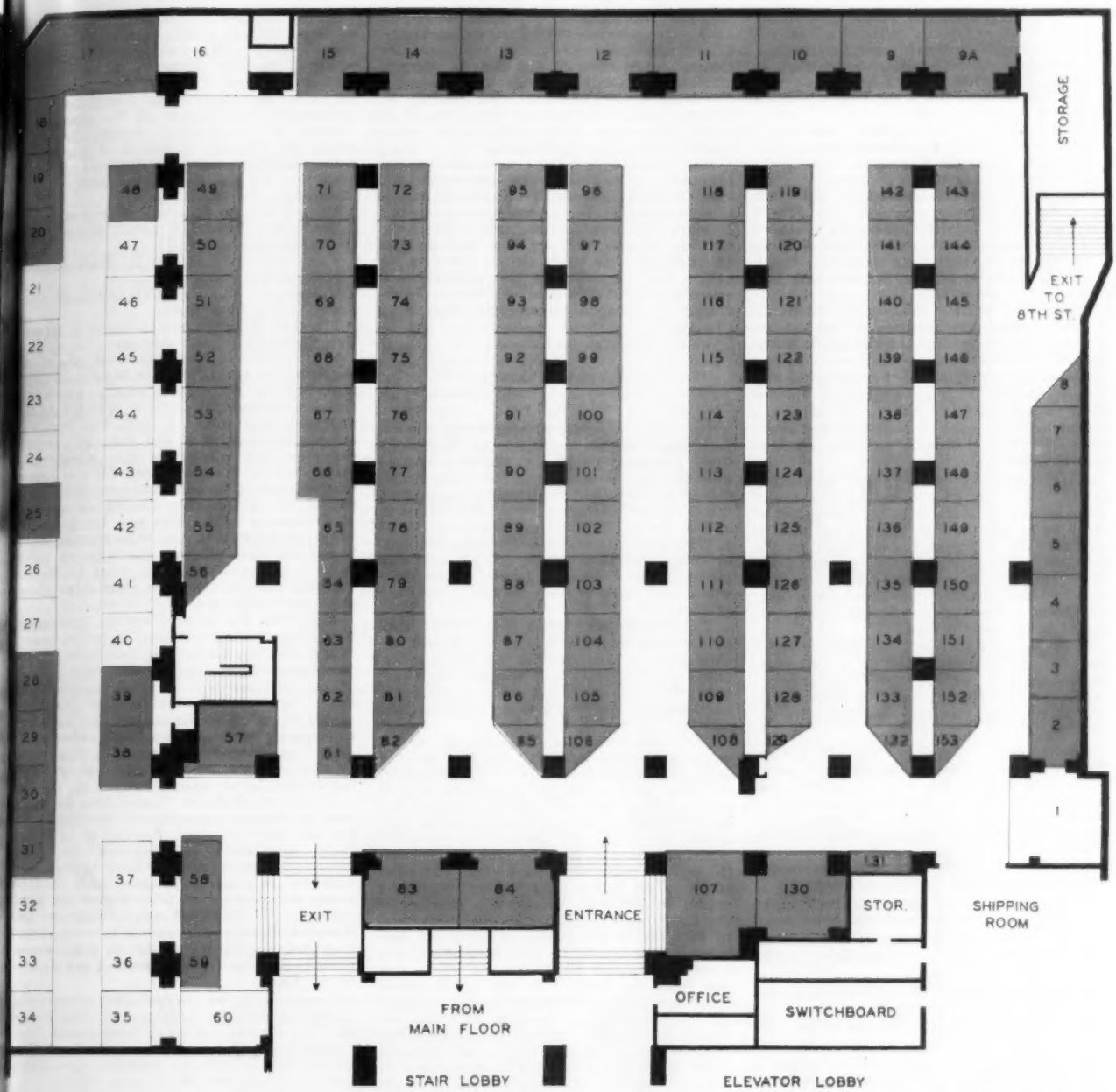


SPACE RESERVED TO DATE (SHOWN IN GREEN), SECOND ANNUAL INSTRUMENT CONFERENCE AND EXHIBIT.

EXHIBITORS TO DATE

Aeroquip Co., Inc.
Aircraft-Marine Products, Inc.
A. S. Aloe Co.
American Meter Co.
Askania Regulator Co.
Associated Research, Inc.
Autoflight Instrument Div., G. M. Giannini & Co., Inc.
Autotron Co.
Bailey Meter Co.
Baird Associates
Barton Instrument Co.
James G. Biddle Co.
Bristol Co.
Brookfield Engineering Labs.
Brown Instrument Co.
Brush Development Co.
Builders-Providence, Inc.
Buffalo Meter Co.
Burgess Battery Co.
Caldwell-Clements, Inc.
Carson Micrometer Co.
Chicago Metal Hose Co.
Commercial Research Labs.
Conoflow Corp.
Consolidated Engineering Corp.
Continental Equipment Co.
R. W. Cramer Co., Inc.
Davis Emergency Equipment Co.
F. W. Dwyer Mfg. Co.
Electro Products Labs., Inc.
Ellison Draft Gage Co., Inc.
Engis Equipment Co.
Equipoise Controls
Esterline-Angus Co.
Fischer & Porter Co.
Fisher Governor Co.
Foxboro Co.
Fulton Sylphon Co.
Gaertner Scientific Corp.
General Electric Co.
General Meters & Controls Co.
Claud S. Gordon Co.
Gotham Instrument Co.
Gow-Mac Instrument Co.
Hagan Corp.
Hammel-Dahl Co.
Hays Corp.
H-B Instrument Co.
Helicoid Gage Div., American Chain & Cable Co.
Illinois Testing Labs., Inc.
Industrial Instruments, Inc.
Instruments Publishing Co.
J-B-T Instruments, Inc.
Jerguson Gage & Valve Co.
Kieley & Mueller, Inc.
Leeds & Northrup Co.
Leslie Co.
Linde Air Products Co.
Liquidometer Corp.
Macbeth Corp.
Magnetrol, Inc.
Manning, Maxwell & Moore, Inc.
Mason-Neilan Regulator Co.
McAlear Mfg. Div., Climax Industries, Inc.
Mercoid Corp.
Meriam Instrument Co.
Mine Safety Appliances Co.
J. W. Murphy Co.
Murphy & Dickey Co.
Nielsen & Fryer
Palmer Thermometers, Inc.
Paragon Electric Co.
Penn Industrial Instrument Corp.
Permo, Inc.
Permutit Co.
Photoswitch, Inc.
Physicists Research Co.
Plummer & Kershaw
Precision Thermometer & Inst. Co.
Production Instrument Co.
R-S Products Corp.
Refinery Supply Co.
Republic Flow Meters Co.
Roller-Smith Div., Realty and Industrial Corp.
Rowe Radio Research Lab. Co.
Sarco Co., Inc.
Schutte & Koerting Co.
Seedburo Equipment Co.
Seely Instrument Co., Inc.
Shallcross Mfg. Co.
Simplex Valve & Meter Co.
Simpson Electric Co.
Sorensen & Co.
South Bend Lathe Works
Herman H. Sticht Co.
Standard Electric Time Co.
Superior Electric Co.
Surty Co.
C. J. Tagliabue Div., Portable Products Corp.
Taylor Instrument Cos.
Telechron, Inc.
H. O. Trerice Co.
Trimount Instrument Co.
Trinity Equipment Corp.
Triplett Electrical Instrument Co.
Veeder-Root, Inc.
Vernon-Benshoff Co.
Victoreen Instrument Co.
Walker-Jimieson, Inc.
Wallace & Tiernan Products Co., Inc.
W. M. Welch Scientific Co.
Weston Electrical Instrument Co.
Wheelco Instruments Co.
H. A. Wilson Co.
John Worley Jewel Co.

Porter Hart, Freeport, Texas (non-member).

David Hostelder, New Jersey Section.

J. Johnston, Jr., Philadelphia Section.

J. C. Kerley, New Jersey Section.

Anker E. Krogh, S.A.M.A. Representative (also I.S.A., Phila. Sec.).

H. M. McCarthy, New Jersey Section.

H. F. Moore, New Jersey Section.

A. Novak, Oak Ridge Section.

R. D. Webb, Charleston Section.

The following sub-committee chairmen have been actively engaged for some months on the projects assigned to them and it is expected that the results of their work will be released very shortly:

H. M. McCarthy—Thermocouple and Extension Wire Standards.

W. G. Brombacher—Manometer Tables.

Other sub-committees which have been activated and have done some preliminary work are as follows:

Flowmeter Installation Practices—R. L. Galley, Chairman. This subject is one of wide scope, and initial efforts are being directed to the release of recommended practices on accessories, such as seals, condensate chambers, etc.

Instrumentation Flow Plan Symbols—David Hostelder, Chairman. A very broad cross-section of users is being canvassed in order to be certain that all systems now in use may be thoroughly considered in the preparation of recommended standards for these symbols. It is planned that the system will also include a comprehensive system for identification numbering and lettering of instrument items.

Recommended Practices for Control Valve and By-pass Installations—W. H. Fortney, Chairman. This sub-committee was only recently set up (April) and no information has as yet been received concerning its activities.

Recommended Practice for Pneumatic Transmission Pressure Range—J. C. Kerley, Chairman. This sub-committee was likewise activated in April, but at a meeting in Cleveland on April 23, it was unanimously agreed to accept the tentative standards proposed by the S.A.M.A. committee working on the same project. Agreement was reached on the following points:

1. Supply pressure for controllers to be not less than 18 and not more than 20 p.s.i.
2. Pressure range for diaphragm motors to be 3 to 15 p.s.i.
3. Pressure range for pneumatic transmitters and receivers as well as for positioning control indices to be 3 to 15 p.s.i.

In addition to the above sub-committees already at work, sub-committees will be appointed as soon as possible to undertake approved projects selected from the following suggested list:

Capillary Protection, Instrument Tubing Supports, Instrument Panel Curbs, Instrument Panel Sections, Alarm Circuits, Outside Instrument Protective Cabinets, Pneumatic Control Circuit Pressure Tests, and Explosion Proof Equipment.

The Committee on Committees, under the chairmanship of W. A. Wildhack, has specified that "The Recommended Practices Committee shall study technical practices in instrumentation and prepare and recommend uniform practices where adoption of such uniformity would simplify work or facilitate general understanding and interchange of information, and promote their general adoption." The Recommended Practices Committee has, according to Mr. Trapnell, approved and accepted this basis of operation, and has in addition adopted a resolution that the committee is in favor of the proposal that the Publications Committee set up a loose-leaf binder system to be issued to all I.S.A. members to include all pertinent and permanent Society literature and to include in such binder a section reserved for the Recommended Practices Committee issues and reports.

The commitee is also requesting that an invitation be extended to the A.S.M.E., Industrial Instruments and Regulators Division, to appoint a liaison member to the I.S.A. Recommended Practices Committee. The Engineering Group of the Recorder Controller Section of S.A.M.A. is already officially represented on the Recommended Practices Committee by Mr. Anker E. Krogh, Brown Instrument Company. It is expected that the A.S.A. will also be represented on the committee soon.

Mr. Trapnell is to be commended on the progress he has made in organizing the Recommended Practices Committee, and it is expected that the recommendations soon to start appearing as a result of the committee's efforts will have a far-reaching effect in both the I.S.A. and in industry.

The next meeting of the committee is scheduled for 12:30 p.m. on Sunday, September 7, 1947, at the Hotel Stevens in Chicago.

Section News

ARUBA

The ninth meeting of the Aruba Section took place on May 6th at the Engineers' Club Building. President MacNutt opened the meeting by exhibiting our recently-received Statutes (or Constitution) signed by the Governor of Curacao Territory. His signature made ours a legal organization as of November 5, 1946. Since the document is in Dutch and most of us are yankees this might lead to some fancy translations when our Holland-born members are not present.

The evening was much livelier than usual. Perhaps this was due to the seating arrangement which gave it all the appearances of a regular "bull session." Anyway, there was a very satisfactory membership participation in the evening's events and reports.

The main event of the evening was a panel discussion arranged by Bill Hughes and his associates on the Project Committee. The purpose of the discussion was to find out what the majority of members desired in the way of meetings, projects, programs, etc.

Art Krottnauer, Bob MacMillan, Lyle McGrew and Stan Chapman were informal speakers on the subject "What benefits I expect to derive by becoming a member of the Instrument Society of Aruba." Art pretty well voiced the opinion of the group during his discussion of (1) Education, and what he thought he would get along this line from the I.S.A., (2) the social aspect of such a group of fellows with something in common, (3) the prestige of being one of a well-organized group, (4) publications available to members, (5) trade contacts, with possibilities of establishing contacts through such an organization which might lead to a better position or an "inside track" not otherwise likely to happen, (6) a matter of good policy to belong to an organization associated with or representing your trade or profession, (7) a possible means of keeping up with new developments, (8) a growing Society with so many possibilities and such a bright future that it is worth joining in the "early days."

Participation in the following discussion period was pretty general and several workable ideas were brought out for the Project Committee to consider. We adjourned at 9:30 and made quite a dent in the pile of sandwiches, doughnuts and coffee supplied through the efforts of the Social and Recreation Committee.

—J. L. LOPEZ, *Sec'y*

CHICAGO

The final meeting of the season for the Chicago Section was a very successful dinner-dance and social evening in conjunction with the annual business meeting at which the new officers for the 1947-48 season were installed. Starting with a social hour in the cocktail lounge, with music by The Three Revelers, the meeting continued with dinner and entertainment in the beautiful Furniture Club of America. Dancing and community singing prolonged the dinner hour until after 8:30.

President Bob Proctor opened the formal business meeting with a brief report on the accomplishments of the Section and of the Society during the past season, following which Treasurer Kraybill presented the financial report of the Section. Chairman Riggs of the Nominating Committee then announced the winners of the election of officers for the coming season, following which Mr. Proctor, on behalf of the Executive Committee, formally declared the winners elected, and turned the meeting over to the new President.

The officers for the coming season are:

President: Stanley A. Gray, Minneapolis-Honeywell Regulator Co.

Vice-President: Ralph R. Siechen, Universal Oil Products Co.

Treasurer: J. H. (Jack) Cuthbert, Carnegie-Illinois Steel Corp.

Floyd E. Ertsman will continue as Executive Secretary of the Section.

With President Gray presiding, the meeting was then turned over to Master of Ceremonies Dick Schoenfeld, who presented three entertainment features which held the audience until almost 11 p.m. The first was the presentation of a $20 hat (gift certificate) to the winner of the membership drive. Several members tied for the honor, so Chairman Charlie Hurst and John Havens of the Membership Committee conducted a drawing to see who won the hat. Miss Sylva Mae Dushkis, the only woman member of the Section, drew the winning name from a hat, and the prize went to Harold Haskett, the Instruments Publishing Company representative in Chicago.

Following the prize drawing, "professor" Don Nielsen presented the "technical paper" of the evening, a hilarious "scientific" report on "Distribution Coefficients." The feature of the evening was then presented—John Booth, professional magician, in "An Hour of Magic and Mind-Reading." The audience was highly pleased with the performance, and everyone, including the wives and sweethearts, agreed that this type of meeting should be an annual affair.

At the unscheduled "Users' Pep Meeting" held on May 5, a number of users gathered for an informal open discussion at which their complaints, suggestions, criticisms, ideas, and offers of help were brought out into the open and aired thoroughly. A good many suggestions were developed for presentation to the incoming Program and Housing Committees, and it is to be hoped that the meeting will result in greater user participation in the activities of the Section in the future.

Outside of the rather intense activity scheduled for the summer in preparation for the Second National Instrument Conference and Exhibit to be held here September 8th to 12th, no meetings are scheduled until the first Monday in October.

We'll see you all in Chicago in September.

—JOHN C. VAALER, *Corr.*

CUMBERLAND

The Cumberland Section held its regular dinner and technical meeting Tuesday, April 29, at the Queen City Hotel. The speaker for the evening was W. F. Pray, Askania Regulator Company, who spoke on the subject "Automatic Proportioning of Gases and Liquids." He very ably handled the subject in the absence of H. J. Velton, who was originally scheduled to present the talk.

Mr. Pray was accompanied by E. R. Engstrom, Manager of the Pittsburgh Division of Askania Regulator Co. We were glad to also welcome S. C. Gewin of the Bristol Company as a guest.

The next meeting will be on Tuesday, May 27. The speaker is to be W. W. Winters, Sales Manager for Automatic Temperature Control Company, and the subject will be "Time Controls in Industry."

—H. E. BISHOP, *Corr.*

DETROIT

The April meeting of the Detroit Section presented a talk by O. G. Rutemiller on the "Motron" Servomechanism. The speaker is a consulting engineer whose background includes work with Westinghouse, the Crosley Corporation, and the W. C. Robinette

ompany, manufacturers of the servo-echanism under discussion.

George M. Chute, Chairman of the ichigan Section, A.I.E.E., acted as techni-l chairman.

Mr. Rutemiller's talk, illustrated by lides, explained the operation of the in-trument, covered its basic theory, and out-lined several interesting control applica-tions. One of the slides showed the mechan-ism used in mixing two oils at the rate of 50 gpm to give an end product that could be kept within a viscosity of 2 Saybolt units at 150 Saybolt. Other uses mentioned in-cluded control of air streams, process level and fabric or thread tension.

The Motron Servo responds to an input of one-half inch-ounce and provides a maxi-mum of 75 inch-pounds output—a torque adequate to actuate most valves, dampers and controls originally designed for man-ual operation.

Guests at the meeting included several faculty members of the University of Michigan at Ann Arbor. Professor Stout, who conducts a course in instrumentation at the University, expressed great interest in the activities of the I.S.A. and of this Section.

Wheelco instruments were featured at the exhibit for this meeting, and drew a large and interested audience.

The next meeting of the Section will be held on Tuesday, May 27 at 8:00 p.m. in the Junior Room of the Horace H. Rackham Building. The subject, "Telemetering Prob-lems in Modern Flight Research," will be discussed by M. H. Nichols, of the Aero-nautical Research Center of the University of Michigan. The monthly exhibit will fea-ture products of the Taco-West Corpora-tion, Chicago, with H. H. Barnum in charge of the demonstration.

The June 23d meeting will feature repre-sentatives from Micromatic Hone Corpora-tion (Monarch Machine Tool Company) and Moore Products Company, who will dis-cuss the subject "Automatic Controls for Production Machinery."

—Siegmund Kulka, *Corr.*

EASTERN NEW YORK

At the May 6th meeting of the Eastern New York Section, L. F. Parachini, of the Weston Electrical Instrument Company, spoke on "Behind the Instrument Dial," a talk concerned with the basic mechanisms in general use for moving a pointer across a scale. As the lecture progressed, he illus-trated it with many of the various types of panel instruments.

The Albany Felt Company has very graciously invited the Eastern New York Section to hold its June 3rd meeting at their plant, Albany-Menands Road (North Broadway), Albany. There will be an in-spection trip through the plant after the regular business meeting, which will con-vene at 8:00 p.m.

The plant inspection trip is to be made with particular attention being given to in-strumentation involved in the manufacture of felts. Due to the nature of the meeting, it is limited to members only.

—W. J. Claffie, Jr., *Sec'y.*

GULF COAST

The April meeting of the Gulf Coast Sec-tion was held Monday, April 21, at Lamar College in Beaumont, with sixty-two mem-bers and guests present.

R. M. Howe, Program Committee Chair-man, announced that Leeds & Northrup Co. was scheduled for May and the Fisher Governor Co. for the month of June.

Section President T. H. Pierson intro-duced the speaker of the evening, D. W. Hilbourn, Service Engineer, Bailey Meter Company, whose slide-illustrated lecture was "Automatic Combustion Control as Ap-plied to Boilers." Mr. Hilbourn's talk was informative and interesting. He described the operation of boilers and presented in considerable detail the fundamentals of combustion control.

Series and Parallel Control were ex-plained, along with the operation and ad-justments of the "Pilotrol," "Standatrol," and the "Averaging Relay."

A lively discussion and question and answer period followed the lecture, and the meeting adjourned at 10:30 p.m.

—A. E. Bunn, *Sec'y-Treas.*

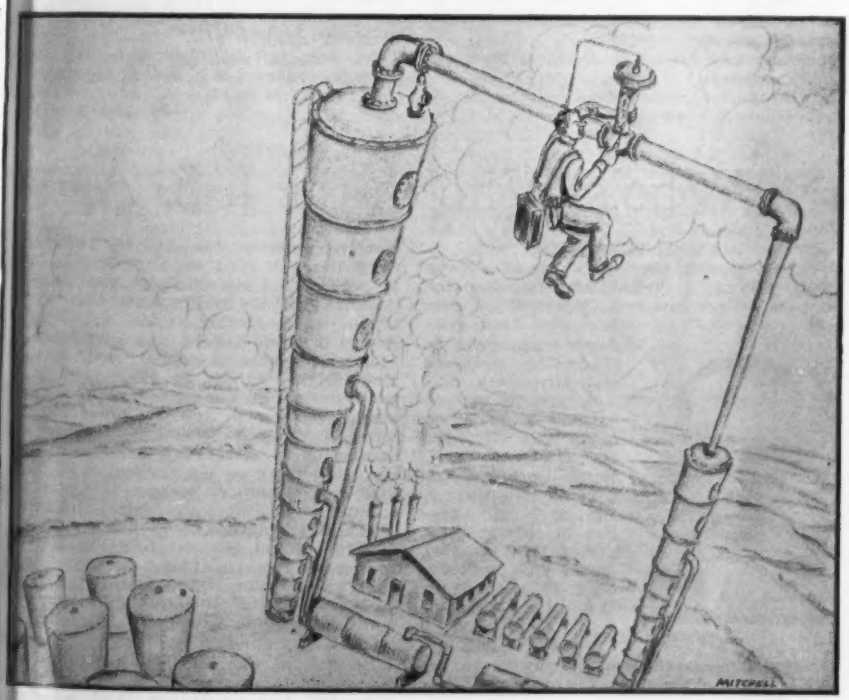
KANSAS CITY

May 27—Main Speaker: J. L. Cottrell, Pittsburgh Meter Division of Rockwell Mfg. Co. Subject, "Orifice Meters and Their In-stallations." Quiz Kids and Basic Lecture.

June 24—Main Speaker; W. R. Gibson, Trans-World Airlines. Subject, "History, Theory and Use of the Aircraft Compass—its Compensation for Deviation and Vari-ation." Basic lecture by Jack Blackburn, Minneapolis-Honeywell Regulator Co.

July and August tours of industrial plants to be announced later.

—W. A. Reichow, *Corr.*



"This oughta qualify me for aircraft instrument mechanic!"

NEW JERSEY

Sid Baran's second attempt to interest the electrical instrument people of Northern New Jersey in the I.S.A. produced an inter-esting meeting; however, they were again conspicuous by their absence. L. G. Gitzen-danner of General Electric Company at Schenectady, spoke on "Electronics in Meas-urements." He explained in an interesting manner how electronics enable us to make measurements easier, faster, and in many cases more accurately.

The regular May meeting presented Bruce Irwin of Hammel-Dahl Company. Mr. Irwin compared the various types of control valves available and gave some very practical rules and illustrations of their proper application. The meeting was followed by a social period when refreshments were served. The fact that members of the Arrangements Com-mittee had difficulty providing chairs to han-dle the unexpectedly large crowd is evidence of the meeting's success. Undoubtedly, the success of the social period after this meet-ing will insure its revival at some of the meetings next year.

The trip to Calco Chemical Company at Bound Brook on June 3rd will wind up the year's activities until September when we hope to have a large group in attendance at the Second Annual Instrument Conference in Chicago.

Harold McCarthy of Standard Oil De-velopment Company will take over the job of Publicity Chairman for the coming year.

—George R. Feeley, *Corr.*

NEW YORK

The Forty-ninth meeting of the New York Section was held at the Men's Faculty Club, Columbia University, on Monday, April 28th. A short business meeting was opened at 8:15 p. m. with the reading of the minutes of the previous meeting. Announcement was made that the topic of the May meeting would be "Relays" and that arrangements are being made for a field trip in June. Professor Carl Kayan presented a brief re-port on the Spring Meeting in Cleveland.

The speaker of the evening, George A. Hall, Jr., of the Bristol Company, Water-bury, Conn., was introduced by President Hildenbrand. The topic which Mr. Hall dis-cussed, "Instrumentation Behind the Iron Curtain," was a factual report of some of his own experiences while in Russia as an engineer for the U. S. Military Supply Com-mission to the Soviet Union, Ford Motor Tire Project.

Mr. Hall opened his talk by saying that the plant was shipped to Russia to make replacement tires for lend-lease equipment, this being considered more economical and space-saving than sending the tires. The plant was complete in every detail and had been in operation for several years in this country. The problem was to reassemble the plant and put it in operation in Russia.

The principal difficulties encountered stemmed from lack of training, carelessness and a general attitude of "so what?" Some of the incidents mentioned were:

1. Separation of identification from equip-ment and consequent confusion.
2. Damage to equipment during trip by freezing and general mishandling.
3. Gross mishandling of equipment while unpacking and assembling.
4. Use of wrong material in assembly of plant, such as using electrical conduit on air and steam pressure lines.
5. General lack of respect for accurate and sensitive equipment, instruments and tools.

Separate incidents were given to illustrate each point. Each would have been quite hu-morous except for the tremendous waste and damage involved. Mr. Hall concluded by giving several incidents of general con-ditions encountered in Moscow.

—Charles D. Corey, *Sec'y.*

NORTHERN INDIANA

The May 19th meeting of the Northern Indiana Section was in the form of a social evening for members and guests and their wives and sweethearts. The affair was held as Tieble's, south of Hammond, where forty

persons enjoyed an excellent chicken dinner served family style. Dinner music was provided by a small orchestra.

Following dinner, A. Francis of Hammond showed reels of colored movies taken on one of his recent trips—a three months' trip through Canada and Alaska. Many of the shots were of flowers, with some particularly good scenes taken during the annual Rose Festival in Portland, Oregon.

Following the movies, and after a short recess, the rest of the evening was given over to music and dancing. Altogether it was a very enjoyable evening for all those present.

—EDWARD L. WHITE, *Corr.*

OAK RIDGE

The regular May 7th meeting of the Oak Ridge Section featured H. A. Straus of Monsanto Chemical Company, Oak Ridge, Tenn., as guest speaker. The dinner portion of the meeting started at 7:00 p. m., followed by the business and technical meeting.

The business meeting was called to order at 8 o'clock by President A. V. Novak, and the minutes of the last meeting were read by Secretary A. H. Fowler. Reports by committee chairmen were given, and N. L. Isenhour, National Delegate, spoke briefly concerning the Cleveland meeting. T. G. Dry, Chairman of the Membership Committee, spoke briefly concerning a drive for new members, and announced that two forum meetings were scheduled to be held in addition to the regular monthly meeting. The subjects to be discussed are "Triode Tubes" and "Flow Calibration." These forums will be conducted by J. R. Mahoney and G. R. Jamieson.

The speaker of the evening was introduced by the Chairman of the Publicity Committee, Charles W. Covey. The subject of Dr. Straus' talk was "Servomechanisms." The lecture was well illustrated with diagrams, sketches and graphs on the blackboard, and was opened by a brief explanation of how anti-aircraft and radar fire-control equipment using servomechanisms was used to bring down enemy planes in great quantities. A basic servo-mechanism was shown on the board and the component parts discussed. At the conclusion of the talk Dr. Straus answered informal questions from the floor.

V. D. Hauck, Chief Engineer of the Friez Instrument Division, Bendix Aviation Corporation, will speak at the June meeting on "Radiosondes."

A seminar session including three or four members of the Oak Ridge Section as speakers will be the program of the July meeting.

At the conclusion of the meeting, C. W. Covey, on behalf of the Program Committee, spoke briefly on the difficulties encountered in securing speakers and papers which will interest all classes of members. It was pointed out that the Program Committee could cope with the problem more satisfactorily if more constructive comments and criticisms were forthcoming from the members themselves, and greater cooperation and membership participation in the affairs of the Society was urged.

—CHAS. W. COVEY, *Corr.*

PHILADELPHIA

The Philadelphia Section held its monthly meeting on April 16th at the Penn-Sheraton Hotel, with over 100 members and visitors present. An innovation at this meeting was the display of new developments in instrumentation by several instrument manufacturers. The consensus of the group was that this type of display is beneficial to instrument men from an educational standpoint, being in line with the Society's plan for advancing instrumentation by educating the members.

Prior to the main topic of the evening we were fortunate to hear William Weber, Instrument Engineer for the Standard Oil Company of Aruba, present a short discussion of the instrumentation at the Aruba Refinery.

The arranged talk for the evening was handled very capably by Paul Wing of the Mason-Nielan Regulator Company. He discussed in detail the displacement-type level controller, comparing it with the buoyancy (or "kidney") type controller and pointing out the advantages of the torque-tube transmission unit, manual reset features and adjustable proportioning band incorporated in the displacement-type instrument.

The evening was "topped off" with refreshments for all.

The 47th meeting of the Philadelphia Section is scheduled for Wednesday, May 21, with Willard N. Greer, Leeds & Northrup Company, as speaker. His subject is to be "Industrial Electrochemical Measurement and Control."

The Social Event of the year, the I.S.A. Annual Dance, is scheduled to be held on June 27th at the Whitemarsh Country Club.

—STUART H. ROGERS, *Corr.*

ST. LOUIS

The regular April meeting of the St. Louis Section was held in the Ball Room at the Hotel York on Monday, April 28. Total attendance was 75, with 45 attending the dinner.

A vote was taken on the changes in the Constitution of the St. Louis Section to bring it into conformity with the National Constitution, and the changes were unanimously approved. The closing date of the Papers Contest was extended to May 19th, and the prizes will be awarded at the May 26th meeting.

The speaker of the evening was Lou Gess, Manager of the Sales Application Engineering Department of Brown Instrument Company, who spoke on "Flow Metering." Mr. Gess outlined the early history of flow meters and then went on to some of the newer designs. He also discussed factors that cause inaccuracy, such as dirt on orifice plates, air pockets in meter lines, dirty meter body surfaces, inaccurate location of taps at the orifice, difference of level of reservoirs in steam metering, etc. The importance of regular lubrication of pressure tight bearings was also stressed.

Mr. Gess stated that the first patent granted on a flow meter of the differential type was dated 1882, and that most of the early work was done in the Pittsburgh Natural Gas district, on gas flow. The first differential unit was a pitot tube, and it was used to bill gas customers. Accuracy was checked against discharge into gas holders.

The talk was illustrated with slides, and was very interesting and well received.

New officers of the Section, elected to serve for one year beginning June 1, 1947, are as follows:

Chairman: Orland G. Forcade, Shell Oil Company.

Vice-Chairman: Landon C. Lodge, Geo. S. Mepham Corp.

Secretary: Wm. G. Lee, National Lead Co.

Treasurer: Roy Finch, Owens-Illinois Glass Co.

Program Committee Chairman: E. O'Brien, O'Brien Equipment Co.

Membership Committee Chairman: P. K. Welch, Leeds & Northrup Co.

Delegate: As before, W. E. Boyle.

Journal Correspondent: Retiring Secretary, H. E. Zeffren.

The May 26th meeting is to be a social evening, including a cocktail hour at 6 p. m., dinner at 7, a short business meeting featuring the introduction of the new officers and an entertainment program at about 8:30. Refreshments will be served after the floor show.

—H. E. ZEFFREN, *Corr.*

WASHINGTON

The April meeting of the Washington Section was held at the Potomac Electric Power Co. Auditorium at 8:00 p. m., Monday, April 21st.

The guest speaker was Charles A. Packard, Chief Engineer, Struthers-Dunn, Inc. Mr. Packard's subject was "Electrical Operation of Small Mechanisms."

The speaker's knowledge and experience in the field of relays and other electrically operated mechanisms, combined with a sense of humor, made his talk both interesting and informative.

Demonstrative equipment and slides and wiring diagrams were used to augment the talk.

Considerable interest was shown by the group in the sample equipment and specific applications of relays and other mechanisms.

—G. M. ROLLS, *Corr.*

WAYNE COUNTY

The May Meeting of the Wayne County Section was held on May 19th at the First Presbyterian Church in Wyandotte, Michigan.

The meeting was opened with the drawing for the door prize, which was won by G. E. Flower. After a short business meeting, a film, "Synthetic Jewel Bearings" was shown.

The speaker of the evening was T. A. Cohen, President of the Taco-West Corp., who spoke on "Electronics as Applied to Liquid Level Control." Mr. Cohen gave a very interesting talk on all the various types of electronics and electrical control as applied to liquid level.

Our June meeting, date to be announced later, is scheduled to be a trip through some local industrial plant.

—W. G. BAKER, *Corr.*

Who's Who in the I. S. A.

DR. R. H. MUNCH

Ralph Munch, I.S.A. Vice President, was born May 5, 1911 at Lafayette, Indiana, but he did not remain a "Hoosier" for long.

His grade school days were spent in Danville, Rockford and Monmouth, Illinois, and he attended high school in Monmouth, Chicago and Chapel Hill, North Carolina. Entering the University of North Carolina in 1927, he was graduated in 1931 with a B.S. in Chemistry. He received his M.S. in Chemistry also from North Carolina in 1932, and almost immediately started working for his Ph.D. at Northwestern University, Evanston, Ill.

By doing laboratory glassblowing, by a teaching assistantship, and by working at the Century of Progress Exposition in 1933, Ralph financed his scholastic work and obtained his Ph.D. in Physical Chemistry in 1935. He very shortly became a Rockefeller Research Assistant at the University of Chicago, working on application of spectrophotometric methods to biochemical problems. In 1937 he accepted a position as research chemist in the St. Louis Laboratories of Monsanto Chemical Company, and has remained with that organization since. His work there on the application of physicochemical methods to process control led to interest in automatic control and industrial instrumentation.

Ralph joined the St. Louis Society for Instrumentation in 1944, and that same year was appointed Contributing Editor for *Industrial and Engineering Chemistry*, for which publication he writes a monthly column on Instrumentation.

In 1945, he was elected a member of the Executive Committee of the St. Louis Society for Instrumentation, and acted as delegate for this group at the October

1945) Pittsburgh meeting prior to the formation of the Instrument Society of America. In 1946 he was elected Chairman of the St. Louis group, which had become the St. Louis Section of the I.S.A., and in September of that year he was elected a Vice-President of the National organization. He is also chairman of the Publications Committee. His Chairmanship of the St. Louis Section has only recently expired.

Ralph is a member of the American Chemical Society, an associate member of the Optical Society of America, and a member of the Executive Committee of the I.S.A.S. Chemical Research Conference on Instrumentation for 1947 (formerly the Gibson Island Conference).

In 1935 Ralph married Charlotte Erwin of Kenilworth, Illinois, and they make their home at 303 Planthurst Road, Webster Groves, Mo. Five children, including twins, are Ralph's pride and joy—John, 9; Mary, 6; Ralph, 4; and Charles and Charlotte, 1½. With all the activity around the Munch home, there isn't too much time left for Ralph to putter around with his hobbies, metal working and glass blowing, but he does manage to enjoy some reading once in a while.

WILLIAM E. BOYLE

"Bill" Boyle, St. Louis Section Delegate, can almost be considered one of the "old-timers" in the instrument field, but with all his accomplishments he was much too modest in the information he submitted to Ye Editor for this little sketch. A little prodding brought out the following facts, however, and even if he won't say how old he is, it can be proven that he has led a full and useful life to date.

Bill's formal education includes Pre-Mining Engineering at Regis College, Denver, Colorado, some special tutorage in Mineralogy, and Metallurgy at the University of Southern California. Among his activities since then, he installed heat treating equipment and organized an instrument department for Consolidated Aircraft; was Instrument Engineer for Gramps Oil and Refining Company of Colorado and New Mexico; was Motor Supervisor for the Denver and Rio Grande Western Railroad; and Mining Engineer for the Colorado Fuel and Iron Company. His mining experience at that time included Carnotite operations in Colorado—this being one of the sources of uranium during the last war.

For the past four years Bill has been employed by the Shell Oil Company as Instrument Engineer, having gone to St. Louis from California to start the instrumentation on Shell's catalytic cracking units. On February 1, 1947, he was appointed Assistant Master Mechanic at the Shell Oil Company refinery at Wood River, Illinois.

Not only as Delegate, but also in other capacities, Bill has been very active in the St. Louis Section for several years. He has held the offices of Vice-President and President of the Section; he was President when the local society became a charter member Section of the I.S.A. When his term of office as President expired, he was elected Delegate to represent the St. Louis Section on the Board of Directors. Bill is a member of the Recommended Practices Committee and of its sub-committee on Thermocouple and Extension Wire Standards.

Bill is a member of the A.S.M.E. and is a Registered Professional Engineer in the State of Illinois. He is married and has three children, two girls and a boy. His son, Bill, Jr., is now attending St. Louis University.

Hobbies? Yes—archery, golf, fly-fishing for mountain trout (when he can get to a stream) and inventing. Bill secured claims on a selenium cell which was the fore-runner of present-day photo-cells, and is a co-owner with T. J. Maloney of a patent on a slide-valve gasoline engine. But, says Bill, with all his inventing, his hobbies, and even his recent promotion, his first love (outside of his wife and family) is and always will be Instrumentation and Control.

The St. Louis Section may well be proud of its Delegate who, in the person of Bill Boyle, has the interests of the Society, its members, and of instrumentation itself at heart.

F. H. TRAPNELL

F. H. Trapnell, Chairman, Recommended Practices Committee, has been in instrument work almost 100 percent since his graduation from the Virginia Military Institute in 1931 with a B.S. degree in Chemistry. Before and immediately after graduation he worked as Sanitary Engineer with the West Virginia State Department of Health, but shortly after joining the DuPont Company in 1932 he was made Assistant Instrument Superintendent at the Belle, W. Va., plant. This position he held until 1941.

"Trap" became involved in considerable instrument design and installation work for the various Ordnance Department plants prior to and during the early part of the war. This soon led to an assignment to Manhattan District work on projects for which DuPont was responsible. The instrument design engineering required on these projects was "Trap's" job and responsibility. He spent an entire year at the Hanford, Washington plant in charge of instrument installation.

"Trap" is now in charge of the Instrumentation Section of the Design Division of DuPont's Engineering Department, and carries the title of Instruments Engineer. He has served on the Applications Committee of the Industrial Instruments and Regulators Division of the A.S.M.E. for the past five years. He also served as Vice-President of the Philadelphia Section of the I.S.A. in 1946. He is now serving as Chairman of the highly important I.S.A. Recommended Practices Committee, and has organized this group into a smoothly functioning unit with several sub-committees and many projects under consideration. A semi-official report of the activities of this committee will be found elsewhere in this issue.

"Trap" is married and has one child, a daughter five years old. The family lives in Wilmington, Delaware.

ISA EMPLOYMENT REGISTER

WHEN: Second Annual Conference and Exhibit of the Instrument Society of America, September 8 through 12, 1947.

WHERE: Hotel Stevens, Chicago, Illinois.

Seeking a Position in Instrumentation? Registration forms and further instructions may be obtained from the Society Office. Pre-registration by applicants is advisable, as records will be made available to prospective employers before the week of the Conference and Exhibit.

Do You Need An Instrument Man? Companies or institutions seeking instrument men are requested to file notice of open positions prior to the week of the Conference and Exhibit so that qualified applicants may be selected for interview.

Interviews Arranged. Representatives of employers and applicants attending the Conference are urged to report to the office of the EMPLOYMENT REGISTER immediately upon arrival so that interviews may be arranged.

The Instrument Society of America, 1117 Wolfendale St., Pittsburgh 12, Pa.

ISA EMPLOYMENT SERVICE

In printing these announcements the Society assumes no obligation as to responsibility of employers. Those replying to announcements should include two copies of their reply. When testimonial documents are to be included, copies of such documents and *not* the originals should be sent. The Society regards acknowledgment by employers of all applications as an act of courtesy but can assume no responsibility for their failure to do so. Address all replies to Employment Committee, Instrument Society of America, 1117 Wolfendale St., Pittsburgh 12, Pa.

—C. F. GOLDCAMP, *Chmn. Employ. Com.*

SITUATIONS OPEN

GRADUATE ENGINEER for electronic and industrial instrumentation in large research laboratory. Considerable practical instrument design and application experience is required. Must be capable of working with and handling technical personnel. Work includes instrumentation application and control in the fields of physics and chemistry. Location, Knoxville, Tenn. Applicant eligible for local area housing. Box 54.

PHYSICIST OR ENGINEER, MS Degree for responsible position and fundamental electronic instrument research design and development in a large research laboratory. Considerable electronic design and experience is required. Must be capable of handling and directing technical personnel. Work includes design of instruments for the detection, measurement and control of physical properties in the fields of physics and chemistry. Location Knoxville, Tenn. Applicant eligible for local area housing. Box 55.

ENGINEER—young graduate familiar with instrument sales and having experience in the instrument field, to sell rotameters and flow indicators in Chicago territory. Box 56.

GRADUATE ENGINEER experienced in the design, manufacture and application of precision pressure regulators and other power plant specialties. Location Chicago and Springfield, Illinois. Box 57.

ENGINEER, recent graduate, degree in mechanical engineering preferred, who is interested in becoming familiar with the industrial instrument field, to handle test work of development and design of regulators and allied products. Location, Chicago. Box 58.

INSTRUMENT MECHANIC by large process manufacturer to service automatic boiler controls, recorders, flow meters; temperature recorders on dryers, cooking kettles and kilns. Must be able to make efficiency checks throughout plant. Salary $250.00 per month. Location Southern Illinois. Box 59.

INSTRUMENT MECHANIC for maintenance and repair of all types of oil refinery instruments including flow controllers, temperature regulators, etc. Hourly basis. Permanent. Location Kentucky. Box 60.

SALES PROMOTION ENGINEER. Leading manufacturer of industrial instruments has unusual opportunity for graduate engineer experienced in the pulp and paper or textile industries; or one with knowledge of process control instrumentation who is interested in applying this knowledge to these industries. Work consists of process control engineering, writing of quotations, order follow-up, and sales correspondence with branch offices and customers. Some traveling involved. Reply giving complete details of experience, education and personal history. Box 61.

Technical Society News

BLOWING-TUBE LIQUID-STEEL PYROMETER

"The blowing-tube pyrometer has a true blackbody temperature scale and a nitrogen bubble at the end of the tube in the liquid steel also appears to closely approach a blackbody radiator," declared L. O. Sordahl and J. W. Bain, of the U. S. Steel Corp.'s Research Laboratory, Kearny, N. J., before the American Institute of Mining and Metallurgical Engineers, Cincinnati, Ohio, April 23. Since a furnace melting chamber under certain conditions also approaches a black body, they stated, the same calibration setting will give true temperature in any such blackbody radiator and also down in the steel bath, if a neutral gas such as nitrogen is used for purging the tube. With normal air purging, oxidation causes an error which increases linearly from a negligibly small value at about 2600°F., to about 65°F. at 3000°F. true temperature. This error appears to be consistent, however, for a normal range of air pressure on the blowing-tube. Furthermore, optical pyrometer readings on most of the common grades of carbon steel appear, strangely enough, to deviate from true temperature in very nearly the same manner. The evidence indicates that the usual effective emittance for open streams (red radiation, 0.65 micron) increases from about 0.40 at 2600°F. to about 0.50 at 3000°F., causing average optical readings corrected for the usual assumed emittance of 0.40 to deviate from the true temperature in nearly the same manner as that for the blowing-tube.

Drs. Sordahl and Bain said that as long as the correction to an optical pyrometer reading on liquid-steel streams in the open remains based upon the accepted average emittance of 0.40, there would seem to be no need to apply the correction for air purging on the blowing-tube temperatures. Present data indicate that bath temperatures by thermocouple and blowing-tube measurements, if corrected to true temperature, will be from 35 to 65°F. low as compared to the tapping or pouring temperature scale now used in most steel plants. This poses a problem for general consideration, since there are a few advantages in the use of a true scale of temperature.

CONTROL ENGINEERING COURSE TO BE GIVEN AT CORNELL

A course in Control Engineering is to be given in the fall term at Cornell University's Sibley School of Mechanical Engineering by C. R. Otto, Assistant Professor, Engineering Materials Department. A general outline of this course follows:

3670—Control Engineering. Either term. Credit three hours. Prerequisite or parallel course: 3X40 and CE6, or equivalents. C. R. Otto.

Two lectures and one laboratory each week. A survey of the commercially-available automatic controllers commonly used in current industrial practice, as to construction, installation requirements and the patterns of control that are available. The problems existing in various plants and processes will be discussed, and the influence of the control modes on process behavior will be studied.

1. *Measurement systems* — Primary elements, signal transmission, response to dynamic variables, installation details.

2. *Processes*—Elements of typical systems, lags, response to upsets, sources of load variations.

3. *Controllers*—Modes of control available, construction and functioning, adjustments.

4. *Final Control Elements*—Positioners, construction, characteristics, installation.

5 *Auxiliaries* — Gage boards, air and electrical systems, remote indications.

6. *Applications*—Actual installations will be inspected and discussed as much as possible throughout the course.

RADIO CLUB DISCUSSES MEGACYCLE METER

The May 9th meeting of the Radio Club of America featured a paper, "The Megacycle Meter," by J. B. Minter, Chief Engineer of Measurements Corp., describing a high-frequency development of the "grid-dip" meter into a compact multi-purpose instrument, which was demonstrated.

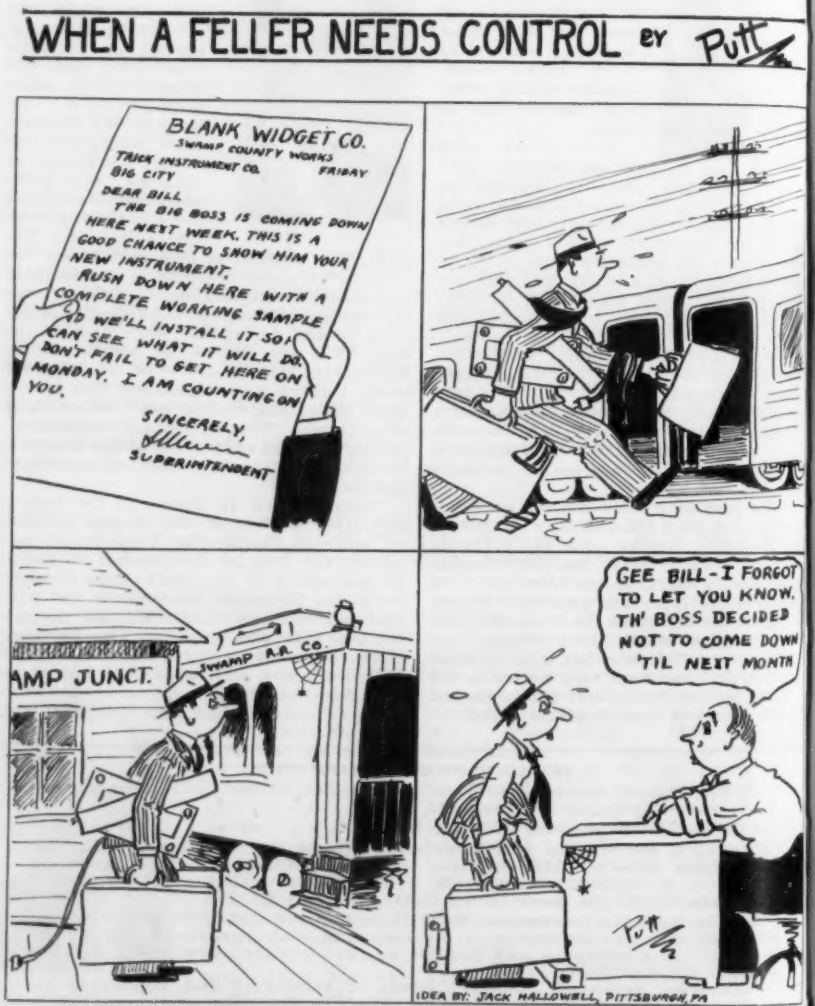
TEXAS A&M's COURSE

The Agricultural and Mechanical College of Texas will conduct its second annual short course in "Instrumentation for the Process Industries" at College Station, August 27-28-29.

The course is outlined on an Engineering level. The speakers scheduled for this year's session will be drawn largely from operating companies. Last year's course, in spite of a delayed start, was attended by more than 200.

Further information can be obtained by writing to Dr. P. G. Murdoch, Engineering Dept., A. & M. College, College Station, Tex.

VISITORS.—Plant tours and dinner discussi with prominent business leaders have been ar ated for groups of foreign students attend Rensselaer Polytechnic Institute, by W. & L. Gurley of Troy, N. Y. On May 5 and 6, Chinese students were the first group invited see the Gurley plant, after a dinner at the T Club where they heard addresses by Z. T. Tsa and Sidney Tsai of the Chun Ho Co., agents the Gurley scientific instruments in China.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IDEA BY: JACK HALLOWELL, PITTSBURGH, PA

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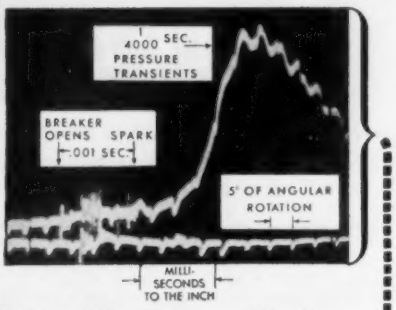

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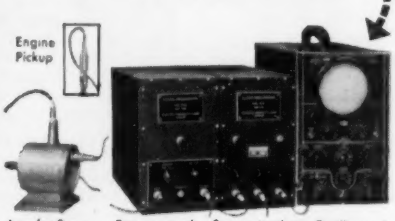

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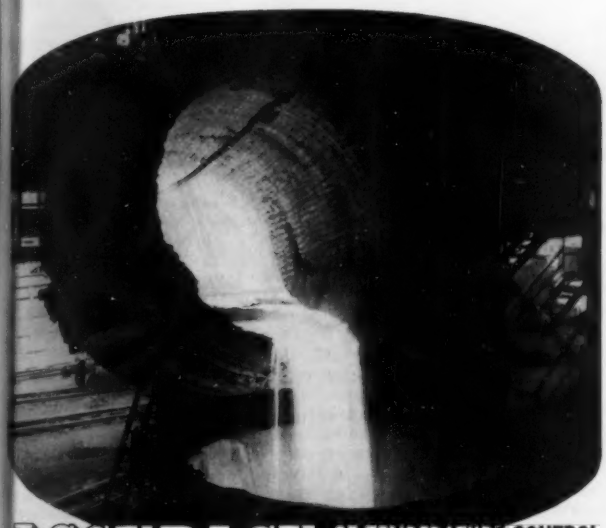

ACCURACY OF TEMPERATURE CONTROL DETERMINES ITS QUALITY

ACCURATE control of temperature or pH is vital to modern heat treating or chemical processing, because only in this way can uniform quality be obtained under mass production conditions.

Potentiometers have made such control possible, and "the heart" of these instruments in most cases, for over 25 years, has been the Eplab Standard Cell. This cell is a "yardstick" for the translation of voltage to temperature. The first commercial cell of its type, constant research has made it "as standard as sterling".

When you buy potentiometers, specify Eplab Standard Cells.

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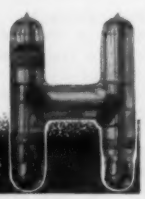

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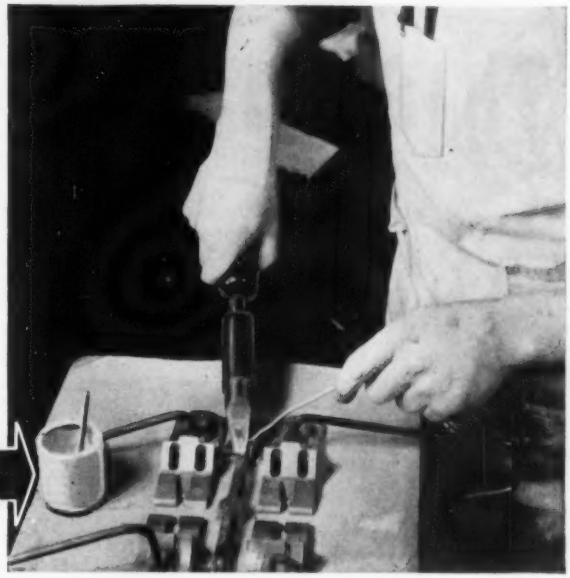

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Manufacturers' New Literature

In this department we report new literature pertaining to instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on page 581.

O-285 **Air Release Valves.** 8-page 8½" × 11" Bulletin No. 140 pictures and describes maker's line of air release valves for water, sewage and industrial use. Simplex Valve & Meter Co., 68th and Upland Sts., Philadelphia 42, Pa.

O-286 **Voltmeters.** 8-page 8½" × 11" Bulletins Nos. 28, 29, 31 and 32 picture and describe "Model VM-27" wide-range vacuum-tube voltmeter; "Model 31" high-voltage voltmeter; "Model 32" high-frequency electronic voltmeter; and "Model 29" high-frequency probe. Alfred W. Barber Laboratories, 34-04 Francis Lewis Blvd., Flushing, N. Y.

O-287 **Navigational Instruments.** 24-page 8½" × 11" Catalog W-2 pictures and describes maker's line of instruments for air and sea navigation. Weems System of Navigation, Annapolis, Md.

O-288 **Wire-wound Resistors.** 6-page 8½" × 11" Bulletin C-2 pictures and describes maker's line of power wire-wound resistors in fixed and adjustable types. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

O-289 **Gaging Tools.** 4-page 4" × 9" bulletin pictures and describes maker's line of gage blocks, thread plug gages, vernier height gages and vernier calipers. Jansson Gage Co., 19208 Glendale Ave., Detroit 23, Mich.

O-290 **Automatic Controllers.** 20-page 8½" × 11" Bulletin No. 3-6400 pictures and describes maker's line of electronic controllers including indicating millivoltmeter controllers, indicating resistance thermometer controllers, indicating potentiometer controllers, automatic fuel and power input controllers, automatic valve positioners, etc. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.

O-291 **Boiler Level Control.** 8-page 8½" × 11" Bulletin 467 is a case record of maker's instruments for boiler water level control installed at the Buzzard Point Plant of Potomac Electric Power Co. Northern Equipment Co., 1945 Grove Drive, Erie 6, Pa.

O-292 **Electrical Snap Gage.** 4-page 8½" × 11" Circular No. 941 pictures and describes the "Electrolimit" snap gage, a portable comparator for checking outside dimensions. Pratt & Whitney Div., West Hartford 1, Conn.

O-293 **Pyrometer Supplies.** 40-page 8½" × 11" Bulletin No. 100-1 is a buyer's guide of maker's pyrometer supplies including thermocouples, protecting tubes, thermocouple wires, lead wires and insulators. Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Pa.

O-294 **"The Bodine Motorgram."** 4-page 8½" × 11" Vol. 27 No. 2 of this house organ contains an article on the application of maker's fractional-horsepower motors to high-precision color cameras for photoengraving. Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill.

O-295 **Internal Micrometer.** 4-page 8½" × 11" Prospectus 140E pictures and describes the "Imicro" internal micrometer, available singly or in sets for measuring internal dimensions from 0.500" to 4.000". Maveg Machine Sales Association Inc., 24-16 Bridge Plaza South, Long Island City 1, N. Y.

O-296 **"General Radio Experimenter."** 8-page 6" × 9" Vol. 21 No. 10 of this house organ contains an article describing the development of radar countermeasures. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

O-297 **Volt-ohm-milliammeter.** 32-page 5" × 7" booklet is an operator's manual for maker's "Model 260" volt-ohm-milliammeter. Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

O-298 **Heating Jackets.** 8-page 8½" × 11" Bulletin C-100 pictures and describes "Gyco" heating jackets for electrical heating of flasks, tubing, etc. Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

O-299 **Rheostatic Voltage Regulator.** 4-page 8½" × 11" bulletin pictures and describes the "Regohm" direct-acting rheostatic type automatic voltage regulator. Electric Regulator Corp., 1915 Park Ave., New York 35, N. Y.

O-300 **Capacitors.** 16-page 8½" × 11" Catalog No. 76 pictures and describes maker's line of capacitors including molded tubular wax impregnated; metal-cased mineral oil grounded; bypass mineral oil impregnated; mica and silvered mica; etc. Sangamo Electric Co., Springfield, Ill.

O-301 **Radio Testers and Electrical Indicating Instruments.** 24-page 8½" × 11" Catalog No. 447 pictures and describes maker's line of instruments including tube and set testers, battery testers, oscillators, signal tracers, cathode-ray oscilloscopes, and panel type electrical indicating instruments. Supreme Instruments Corp., Greenwood, Miss.

O-302 **Transformers.** 4-page 8½" × 11" bulletin describes maker's facilities for manufacturing special types of transformers and pictures some specially engineered designs. Freed Transformer Co., 72 Spring St., New York, N. Y.

O-303 **Hydraulic Presses.** Single sheet 8½" × 11" pictures and describes maker's super high speed hydraulic presses available in several sizes with speeds varying from 50 to 100 1" strokes per minute. Wroble Engineering Co., 1067 Davis Terrace, Schenectady 3, N. Y.

O-304 **Vacuum Monitor.** 4-page 8½" × 11" bulletin pictures and describes the "Skanascope" high-vacuum monitor which indicates by means of color indications on a fluorescent screen the degree of vacuum attained. Distillation Products, Inc., Vacuum Equipment Div., 755 Ridge Road West, Rochester 13, N. Y.

O-305 **Decade Amplifier.** 2-page 8½" × 11" Bulletin B-4 pictures and describes the "Model 102A" decade amplifier, a general-purpose pre-amplifier having stabilized gains of ×100 and ×1000, and maximum gain of approx. ×10,000. Kalbfell Laboratories, 1076 Morena Blvd., San Diego 10, Calif.

O-306 Smoke Detector. 2-page 8½" × [illegible] Bulletin No. 57 pictures and describes [illegible]. 925" smoke detector which indicates [illegible] presence of smoke or haze by employing the principle of reflected light [illegible] the smoke particles. F. W. Dwyer [illegible] Co., 317 S. Western Ave., Chicago, [illegible]

O-307 Stationary Tachometers. 4-page [illegible]" × 11" bulletin pictures and describes maker's line of stationary tachometers with 6" dials. O. Zernickow Co., [illegible] Park Row, New York, N. Y.

O-308 Transverse Testing Machine. 2-page 8½" × 11" Bulletin TT pictures and describes "Model TR-1" transverse testing machine of 10,000 lbs. capacity, 24" maximum span, and 4" opening. Steel City Testing Machines, Inc., 8843 Livernois Ave., Detroit 4, Mich.

O-309 Parabolic Flume. 8-page 8½" × [illegible]" Bulletin No. 210 pictures and describes "Type S" parabolic flume for measuring open flows of water, sewage and industrial liquids. Simplex Valve & Meter Co., 68th and Upland Sts., Philadelphia 42, Pa.

O-310 Input Controllers. 2-page 8½" × [illegible]" Bulletin T-49 pictures and describes maker's manually-adjusted input controllers for control of current input to electric heating elements in furnaces, ovens, etc. Automatic Temperature Control Co., Inc., 34 E. Logan St., Philadelphia 44, Pa.

O-311 Audio Signal Synchronizer. 4-page 8½" × 11" Bulletin No. 34 pictures and describes "Model J" audio signal synchronizer for the synchronization of signals from 2 to 100,000 cps. on input voltages as low as 0.05 volt. Televiso Products Co., 7466 W. Irving Park Rd., Chicago 34, Ill.

O-312 Magnetic Dipping Needle. Single sheet 8½" × 11" pictures and describes the "D1" magnetic dipping needle for locating iron and steel objects underground. Globe Phone Mfg. Corp., Reading, Mass.

O-313 Electronic Supplies. 160-page [illegible]" × 9" Catalog 112 pictures and describes radio and electronic apparatus and components distributed by this company. Allied Radio, 833 W. Jackson Blvd., Chicago 7, Ill.

O-314 Bimetal Thermostats. 4-page [illegible]½" × 11" Bulletin F-2000 pictures and describes "Type S" adjustable and non-adjustable bimetal thermostats for a temperature range of 0°F. to 650°F. Stevens Mfg. Co., Richland Trust Bldg., Mansfield, Ohio.

O-315 Appliance Tester. 2-page 8½" × [illegible]" bulletin pictures and describes "Model 390" volt-amp-wattmeter for use in checking all types of electrical appliances. Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

O-316 Power Analyzer. 2-page 8½" × [illegible]" Bulletin Form 6111 pictures and describes "Model 77" electrical power analyzer, a portable test instrument for a-c. power measurements. Niagara Electrical Instrument Co., 559 Ellicott St., Buffalo 3, N. Y.

O-317 Instrument Panels and Cubicles. [illegible]-page 8½" × 11" bulletin pictures and describes maker's standardized line of panel units, cubicles and accessories. Falstrom Co., Falstrom Court, Passaic, N. J.

O-318 Permanent Magnets. 24-page [illegible]½" × 11" bulletin lists permanent magnet materials and their properties, gives design considerations, and shows demagnetization and energy curves for several types of magnet materials. Arnold Engineering Co., 147 E. Ontario St., Chicago 11, Ill.

O-319 "Black Light Beacon." 4-page [illegible]½" × 11" Vol. 3 No. 5 of this house organ contains several articles on appli-

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cations of black light and fluorescent paints, including one describing an inspection device for tubing interiors and similar applications. Switzer Bros., Inc., 1220 Huron Rd., Cleveland 15, Ohio.

O-320 **Water Demineralizer.** 2-page 8½" × 11" Bulletin No. 111 pictures and describes the "Barnstead Bantam" demineralizer which provides mineral-free water by the use of ion-exchange resins. E. H. Sargent & Co., 155 E. Superior St., Chicago 11, Ill.

O-321 **"The Hydromike."** 4-page 8½" × 11" Issue No. 29 of this house organ contains an article describing the "Stevens" radio registering system for transmitting hydrographic information. Leupold & Stevens Instruments, 4445 N. E. Glisan St., Portland 13, Ore.

O-322 **Relays.** 24-page 8½" × 11" Catalog 10-A pictures and describes maker's line of basic-type relays for a-c. and d-c. operation. Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.

O-323 **Permanent Magnets.** 16-page 8½" × 11" bulletin is devoted to information on the use, design and fabrication of permanent magnets. Thomas & Skinner Steel Products Co., 1058 E. 23rd St., Indianapolis, Ind.

O-324 **Resistance Thermometers.** 8-page 8½" × 11" Bulletin R-900 pictures and describes the "Dynamaster" electrical resistance thermometers for temperatures between —150°F. and 400°F. The Bristol Co., Waterbury 91, Conn.

O-325 **Ultraviolet Monochromators.** 12-page 8½" × 11" Bulletin 801 pictures and describes maker's ultraviolet monochromators in 3 models for the spectral region 200 to 800 mμ with quartz-lithium fluoride optics, and 3 visual-region models (400 to 950 mμ with glass optics. Farrand Optical Co., Inc., Bronx Blvd. & E. 238th St., New York 66, N. Y.

O-326 **Marine Radio Telephone.** 4-page 8½" × 11" bulletin pictures and describes the "Challengaire" marine radio telephone with a built-in direction finder. Electronic Associates, Inc., 61 Brighton Ave., Long Branch, N. J.

O-327 **High-pressure Laboratory Apparatus.** 80-page 8½" × 11" Catalog 406 pictures and describes maker's line of superpressure and catalytic hydrogenation apparatus for pressures up to 100,000 lbs./in.² and temperatures up to 1000°F. Superpressure Division, American Instrument Co., Silver Spring, Md.

O-328 **Signal Generator.** 4-page 8½" × 11" Page 10 of the Electronic Measuring Equipment Catalog pictures and describes "Model YGS-3" signal generator which combines the functions of an r-f. oscillator, an f-m. oscillator, a crystal calibrator, and an audio oscillator. General Electric Co., Electronics Department, Syracuse, N. Y.

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